ENERGYPLUS™

Auxiliary EnergyPlus Programs

To Increase Your Efficiency at
Using EnergyPlus

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Introduction

This document will describe several of the "auxiliary programs" of the EnergyPlus system in more detail. These programs include:

Weather Converter Program (aka "Weather")

Procedure for Ground Temperature creation

Vcompare – To compare two Idd files

Transition_Vold_Vnew – to convert input files from one version to another upon release of a new version

HVAC Templates – Used to assist you in creating HVAC systems

WinEPDraw – Create DXF files from your input files

Input Macros – Use a macro language to increase efficiency in creating EnergyPlus input files

Weather Converter Program

The Weather Converter program is stored in the EnergyPlus folder area under "PreProcess" and subsequently in the "WeatherConverter" folder.

To perform annual/run period simulations in EnergyPlus, one needs weather data. Most weather data is still issued in an hour by hour (hourly) format though as you will see, EnergyPlus and its weather converter can accept data that has a finer resolution on the data (such as every 10 or 15 minutes).

The special weather format (EPW) used in EnergyPlus is a simple, ascii format as is common in the rest of the inputs for EnergyPlus. It is described in the Input Output Reference document and that description will be included here as well.

Background

All building simulation programs employ some means of representing local climatic conditions relative to the building models. For example, Radiance (Ward 1996) needs a description of sky conditions and illuminance values to calculate solar distribution through a window and within a space. Three of the widely used energy simulation programs in the UK and US, ESP-r (ESRU 1999), BLAST (UI 1998), and DOE-2 (Winkelmann et al. 1993) also use weather conditions to simulate the response of a building. But even after 30 years of significant development advances in simulation capabilities, these programs use the same climate representations as in the past—a simple set of hourly temperature, humidity, wind speed and direction, and atmospheric pressure and solar radiation or cloud cover data. These data are often 'typical' data derived from hourly observations at a specific location by the national weather service or meteorological office. Examples of these typical data include TMY2 (NREL 1995) and WYEC2 (ASHRAE 1997) in the United States and Canada and TRY (CEC 1985) in Europe. The TMY2 and WYEC2 typical weather years contain more solar radiation and illumination data than older formats such as TMY (NCDC 1983), WYEC (ASHRAE 1985), and TRY (NCDC 1981) in the U.S. Crawley (1998) demonstrated that the methods used to select data for the US TMY2 and European TRY data sets better fits the long-term climate patterns.

Radiation and illumination data are becoming increasingly necessary in simulation programs. Anyone who has ever attempted to measure daylight factors will be familiar with the fluctuations in lighting levels under partly cloudy conditions. The expansion and contraction of lightweight building components also shares sensitivity to rapid fluctuations in solar radiation. Single-sided ventilation is dependant on wind pressure fluctuations and pedestrians in many cities are acquainted with the disarming tendency of the wind to guest and change direction. It is increasingly the case that design questions touch on such issues.

In a research context, the advent of tools such as LabVIEW (National Instruments Corporation 1999) have made it possible for increasing numbers of researchers to acquire and process test-cell data. The increasing use of building energy management systems (BEMS) has also provided high frequency information from which simulation could be used as a predictive tool for future control strategies. Other issues of control, particularly of advanced daylighting control require sub-hourly illumination data to ensure that possible control regimes are tested under realistic conditions. Janak (1997) observed that the differences between 5 minute and hourly illumination data could result in prediction variations approaching 40%.

Thus far, projects that mix empirical and simulation-based work have had to store and access such data via temporal database facilities (ESRU 1999). As the number of high quality datasets increases so does the need to encapsulate such information in a form that can be broadly distributed. The simulation community must also consider the uncertainty in high

frequency performance predictions that are based on boundary conditions that have been sampled at one or two magnitudes less temporal resolution.

The simulation community must also consider practitioner demands and issues of quality assurance. Someone who is not a native of Copenhagen may not know that there are three or four recognizable patterns of winter weather that should be included in detailed assessments. A data set that lacks documentation or is dependent on separately held lists of assumptions can be effectively useless.

In the absence of data within the weather data format, the simulation programs must calculate these data often with older calculation methods. As the simulation programs have become more capable, data at hourly resolution is no longer enough—interpolating between hourly observations does not accurately represent weather conditions that change much more frequently such as illumination.

We have developed a new, generalized weather data format for use by energy simulation programs has been developed and adopted by both ESP-r (in the UK) and EnergyPlus (in the US). Anticipating the need for data at time steps less than one hour, the format includes a minute field to facilitate the use of sub hourly data. The data include basic location identifiers such as location name, data source, latitude, longitude, time zone, elevation, peak design conditions, holidays, daylight saving period, typical and extreme periods, ground temperatures, period(s) covered by the data and space for descriptive comments. The time step data include dry bulb and dew point temperature, relative humidity, station pressure, solar radiation (global, extraterrestrial, horizontal infrared, direct, and diffuse), illuminance, wind direction and speed, sky cover, and current weather.

New Weather Format for Simulation Programs

For these reasons, we developed a new generalized weather data format for use with two major simulation programs—ESP-r and EnergyPlus (Crawley et al. 1999). All the data are in SI units. The format is simple, text-based with comma-separated data. It is based on the data available within the TMY2 weather format but has been rearranged to facilitate visual inspection of the data. The TMY2 data are a strict, position-specific format—filling missing data with nines and zero values with zeroes. The new weather data format contains commas to facilitate data reading and analysis with spreadsheet programs. By eliminating redundant 'fill' values, the size of each file is only slightly larger than the original TMY2 format. Details about the TMY2 format can be found in the TMY2 User's manual (see references at the end of this section).

The traditional distribution of data source and uncertainty flags within the raw data fields carries with it not only the need for many field separators, it obfuscates the relationships between non-numerical data. In a set of minute data, which could easily require hundreds of thousands of records, the space penalty is considerable. In the E/E file format, all data source and uncertainty fields have been clumped together as a single field immediately following the day and time stamp. For applications where uncertainty is not an issue such data can be easily ignored. When it is important, a single text field is conceptually and computationally easy to parse.

Another difference between the EnergyPlus/ESP-r (E/E) format and TMY2 is the addition of two new data fields—minute and infrared sky. The minute field facilitates use of data observed at intervals of less than one hour such as measured data from a research study of energy efficiency for a particular building. This will allow easier and more accurate calibration of a simulation model to measured data than possible in the past. The infrared sky field allows the programs to calculate the effective sky temperature for re-radiation during nighttime.

The last difference is that a full year of data (such as 8760 hours) is not required—subsets of years are acceptable. Which periods are covered by the data is described in the files. Periods of typical weather patterns based on analysis of the data are also included within the

format. A side-by-side comparison of data included in the E/E weather format with data previously used by ESP-r, DOE-2, and BLAST is shown in Table 1.   A deficiency noted within ESP-r for example is the lack of correcting air volumes for elevation change—many of the users of ESP-r are in relatively low elevations. For DOE-2 and BLAST, neither program used illumination data in daylighting calculations or infrared sky temperatures—it was always recalculated at time of use.

By including the uncertainty and data source information found in TMY2, users now can evaluate the potential impact of weather variability on the performance of the building.

McDonald and Strachan (1998) are introducing uncertainty analysis into ESP-r.

We use the EnergyPlus data dictionary format to describe the E/E weather data set. (See the end of this document).   Each line in the format is preceded by a keyword such as LOCATION, DESIGN CONDITIONS, followed by a list of variables beginning either with A or N and a number. A stands for alphanumeric; N for numeric. The number following A/N is the sequence of that number in the keyword list. Commas separate data. (Refer to the IDD Conventions document in "Getting Started" for further explanation of the format). The header information consists of eight lines (keywords):   LOCATION, DESIGN CONDITIONS, TYPICAL/EXTREME PERIODS, GROUND TEMPERATURES, HOLIDAYS/DAYLIGHT SAVINGS, COMMENTS 1, COMMENTS 2, and DATA PERIODS. This is followed by the time step data.

The first eight lines or header within each E/E weather file define basic location information such as longitude, latitude, time zone, elevation, annual design conditions, monthly average ground temperatures, typical and extreme periods, holidays/daylight saving periods, and data periods included.   There is also space for users to document any special features or information about the file such as sources of data.

Weather Data Availability

Typically, acquisition of weather data has been a user's burden. Though this will remain the case in many instances for EnergyPlus users, the EnergyPlus team has been successful in making a wealth of US, Canadian and International data available to our users.   To summarize, the weather data for 583 locations is available at the EnergyPlus web site: www.energyplus.gov

In specific, you may download data files for locations:

- 279 USA (a mixture of TMY2, TMY, and CTZ data)

  The 237 USA locations in the TMY2 Data Set, 38 locations from the TMY data set that were not duplicated when the TMY2 data set was produced, and 4 locations from the CTZ data set that were not duplicated when the CTZ2 data set was produced.

- 16 California Climate Zones

  The 16 locations in the California Climate Zone Revision 2 (CTZ2) data set.

- 55 Canada (CWEC data)

  The 55 locations from the CWEC data set.

- 233 International

  2 locations from the TMY2 data set. 4 locations from the TMY data set that were not duplicated in the TMY2 data set. 227 locations from the IWEC data set.

This data has been selected with the energy simulation user in mind. All the data (as well as the statistical reports – described later in this document) is downloadable for individual locations.

Table 1. Comparison of E/E with ESP-r, DOE-2, and BLAST Weather Data Formats

Data Element	DOE-2	BLAST	ESP-r	E/E
Location (name, latitude, longitude, elevation, time zone)	X	X	X	X
Data source				X
Commentary			X	X
Design conditions				X
Typical/extreme periods			X	X
Data periods				X
Holiday/Daylight Saving		X		X
Solar Angles/Equation of Time Hours		X		
Degree Days		X		X
Year	X	X	X	X
Month	X	X	X	X
Day	X	X	X	X
Hour	X	X	X	X
Minute				X
Data source and uncertainty flags				X
Dry bulb temperature	X	X	X	X
Wet bulb temperature	X	X		
Dew point temperature	X			X
Atmospheric station pressure	X	X		X
Humidity ratio	X	X		
Relative humidity			X	X
Enthalpy	X			
Density	X			
Wind Speed	X	X	X	X
Wind Direction	X	X	X	X
Infrared Sky Temperature		X		X
Solar Radiation (global, normal, diffuse)	X	X	X	X
Illuminance (global, normal, diffuse)				X
Sky cover (cloud amount)	X			X
Opaque sky cover				X
Visibility				X
Ceiling height				X
Clearness (monthly)	X			
Ground temperatures (monthly)	X			X
Present weather observation and codes (rain, snow)		X		X
Precipitable water				X
Aerosol optical depth				X
Snow depth				X
Days since last snowfall				X

Weather Converter Use

We developed a utility for the E/E format to read standard weather service file types such as SAMSON and newer 'typical year' weather files such as TMY2, WYEC2, and IWEC. The utility also reads ESP-r (CLM format), DOE-2 (fmt format) and BLAST (Ascii format) files.

The utility translates and extends typical weather data into the E/E format. The processor makes the calculations necessary for supplying data (when data is missing) and calculates the Horizontal Infrared Radiation Intensity values—not typically currently an observed value reported by the meteorological offices through the world. The utility also prepares an statistical summary of the weather data set as part of the processing. An additional "output format" from the utility is a comma-delimited file that can easily be imported into a spreadsheet program such as Excel™ for further user perusal, charting and/or editing.

The utility consists of two parts: a user interface that executes on standard Wintel systems and a DLL that does the work of the processing. The DLL interface will be described in a later section for those developers who might wish to access it directly.

The user front end is a simple to use program with standard graphical user interface menus. For convenience, it automatically opens with the "convert" option.
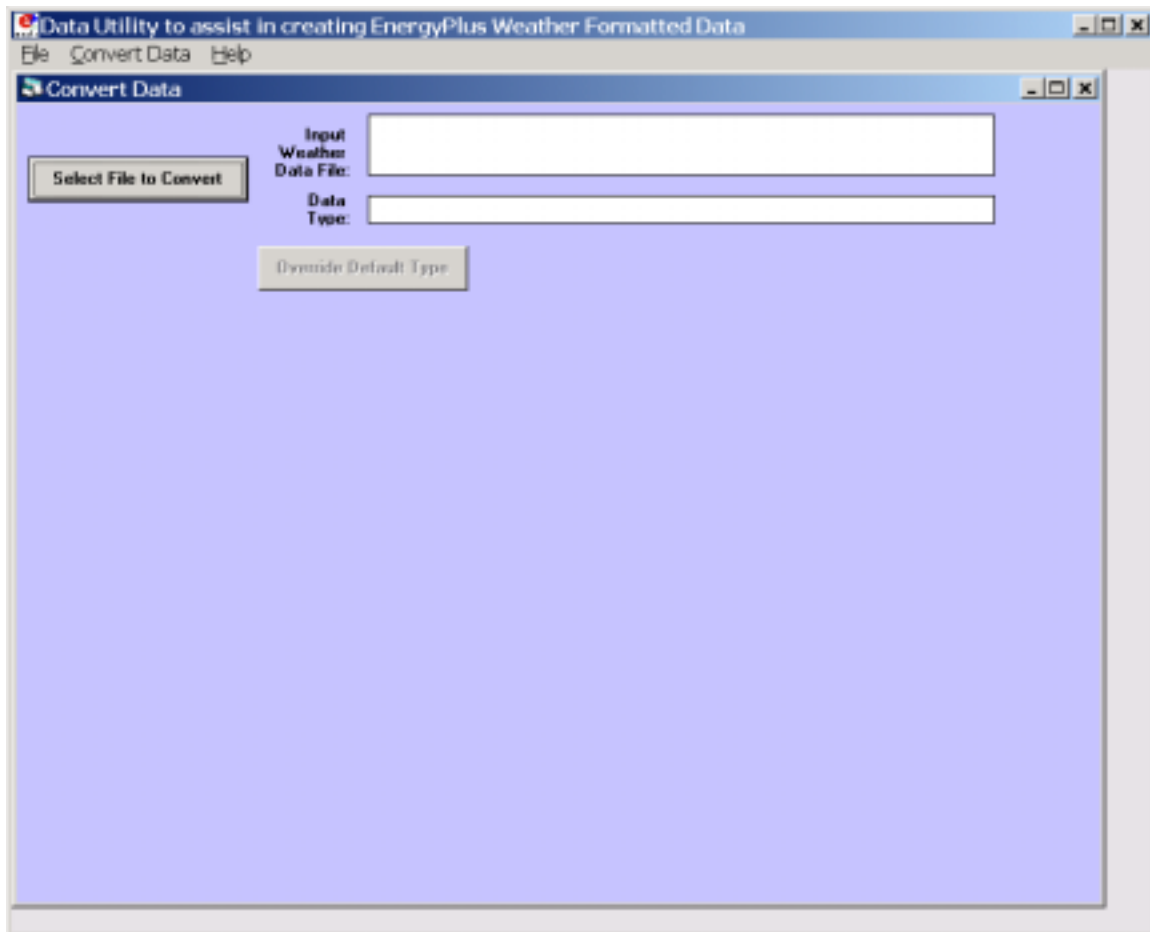
Figure 1. Main menu screen of the Weather Converter Utility

File Menu

The file menu has (currently – April 2003) four options:

Fix Out of Range Data

This is a toggle option that once selected is saved in the registry with other options (for example, screen size) for the program. As shown in the IDD type description of the Weather Data, there are minimum and maximum values for several of the fields.   The weather converter program can ignore these (and just report them) or it can try to fix them with appropriate values. If the option is "checked", then the processor will try to fix the data; if it is blank, the processor will not fix the data though it will report any out of range data that it finds.

Select Delta DB Trigger

Depending on the quality control and accuracy of the weather data collection, time period (usually hour to hour) changes in some data values may make the data suspect for that time period. This selection brings up the screen shown below and will allow the user some control over the actual value reporting. Note that this data is not "fixed", merely reported by the program in the audit output file.
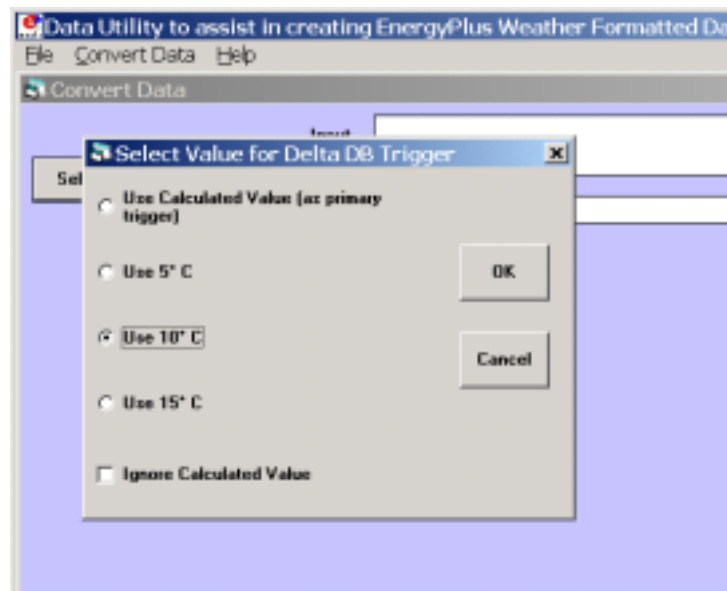
Figure 2. Delta DB Trigger Selection

Though only one "trigger" value is selected from this screen, consecutive values of dry-bulb temperature, dew-point temperature and wind speed are reported using appropriate calculated values. Both dew-point and wind speed use a calculated value based on mean of their values over the entire data period and standard deviation from that mean, heuristically derived.

An excerpt from the audit file is illustrative:

```
Average Delta DB Change=  0.78°C ; Std Dev=  0.83°C
 Average Delta DP Change=  0.68°C ; Std Dev=  0.78°C
 Average Delta Relative Humidity Change=  4.02% ; Std Dev=  4.22%
 Average Delta Wind Speed Change=  0.91m/s ; Std Dev=  0.88m/s
 Hourly Dry Bulb temperature change trigger = minimum of  12.13°C  and  10.°C
    12.13°C = calculated trigger based on mean change in dry-bulb temperature and standard deviation
shown above
    10.°C = trigger set by user
```

Here the calculated DB trigger would be 12.13°C, but the user chosen trigger is 10°C. Changes >= 10°C will be reported.

```
- Delta DB/DP Range Triggered for Apr 30
-    Change in DB= 11.60°C, Hour=14
```

Such detail allows the user to hand edit the incoming data, if desired.

Delete File

You may use this menu option to browse your computer and delete files.

Exit

This choice exits the program.

Converting Data

This screen is automatically shown when you start the program – it will allow you to select raw data for processing, change the default type (based on file extension), select the kind of conversion you want, select where and what name to store for the processed data, and process the data. An "almost" completed screen shows:

Figure 3. Convert Data Screen selections

The screen is navigated by choosing the following buttons on the left portion of the screen. Interpretation from the program is shown in the status boxes on the right portion of the screen.

Select File to Convert

Selecting this command button brings up a common dialog interface that allows you to select a file for conversion from a specific set of default file extensions. These are shown in the following table.

Table 2. Input File Extensions with their implied Data types

File Extension	Implicit Data File Type
Tm2	TMY2
IWC	IWEC
WY2	WYEC2
DAT	SAMSON
EPW	EnergyPlus E/E
FMT	DOE-2 Formatted File
CSV	Comma Delimited File
CLM	ESP-r Climate Formatted File
ASC	BLAST ASCII
TMY	TMY
LST	Processing List of Files

Of course, the "all files" (*.*) may be used as well. If the file selected is not one of the above types, you will be cautioned to use the "override default type" button to select the correct type before proceeding. Most of the data file types are described in other publications and won't be described in detail here. The LST data type allows you to specify a list of files to be "batch processed". The format of this file is very simple (however, the default extensions from the preceding table **must** be used).

Note on the input CSV format: Currently, the CSV format must mirror the output CSV format very closely. The processor expects a Location header record and the headers for the data fields as a minimum (as well as the data that supports those header fields).

Each line of the LST file can have a columnar structure as shown in the following table or can have the input file separated from the output file with a TAB character.

Table 3. LST File Structure

Columns	Contents
1-45	Name of Input File to be Processed
46-105 (or follow the first name with a {TAB})	Output File with:
	EPW – same as output type "EPW"
	CSV – same as output type "CSV"
	Both – same as output type "both"
	Rpt – same as output type "rpt"

Override Default Type

This button is used as described above to select the correct data type for a file that might have one of the standard "default" extensions but may, in fact, be a data file of an entirely different type. For example, the BLAST ASCII files as they exist on the BLAST CD have extensions of .dat – our default type for the SAMSON data. You must select the proper data type for your data or the processor probably won't work anywhere near what you expect.

Select Output Format

You may select from four options of output format:

- EPW Format -- both an epw file and a statistical report file are produced

- CSV Format – both a csv file and a statistical report file are produced

- Both EPW and CSV – epw, csv, and statistical report files are produced

- Rpt only – only a statistical report file is produced (output extension is "stat")

- TMY2 – if your input file was a EPW or CSV, you can save as a TMY2 (extension "tm2") format

Note that the CSV file is very similar to the EPW format file but is ready to be imported into a spreadsheet program such as Excel™ and has some additional "header" records in front of each EPW style header record

Save File As…

This button allows you to select the location to save your file set from the output format selection. The utility automatically places a "data type" extension on the file name to show its original data file type.

> Note on Save As… Since you select the "save as" file name from a dialog, the processor DOES NOT warn you of overwriting previous files of the same name. In addition, if you have previously saved several types (e.g. EPW and CSV) but this time only save the RPT – it DOES NOT create new of the others nor does it delete the previous ones.

Convert File

Pressing this button causes the processing of the data to proceed. If you choose a ".lst" input format, you will see messages as each once is completed and/or has errors. If you choose a single data file, you will see a similar message box once the processing is done (or has terminated due to errors).

Help

No online help is yet implemented. This brings up an "about" box for the program.

Reports/Files Produced by the Weather Converter

Minimally, two outputs are produced for every weather converter run: an audit / log file and a statistical report file. The audit / log file shows details of the processing (including any errors) as well as the statistical report. The statistical report produced from the weather conversion process is a short, but complete, picture of the weather data on the file. A single file (.stat extension) is produced of the "statistics" about the data file. A feature of the weather converter is to look in several design condition files for possible design conditions for the location from the stored design condition files (source: ASHRAE Handbook of Fundamentals,

2001). If found (WMO (World Meteorological Organization) id is used for matching), these will be shown in the report as well as included in the output data files (EPW and CSV, as applicable). In addition, the Köppen classification scheme is used to characterize the climate based on the data file's contents. Other statistics are given as well to help you visualize the data.

In the "reporting" section of the file, each line contains "tab-delimited" elements. This will allow you to easily place the data into a spreadsheet program for further refinement but the tabs are not as intrusive for "normal viewing" as commas.

Audit / Log File

As an example, the initial portion of an audit file is shown (illustrating the error reporting):

```
-Input File Type=WY2, with FileName=D:\DevTests\Release\WeatherData\04772.wy2
 -Out of Range Data items will be corrected.
 Warning ** Dew Point=   5.00°C > Dry Bulb=   4.90°C on date= 5/ 1 at hour= 4
 DewPoint set equal to DryBulb
 Warning ** Dew Point=   4.80°C > Dry Bulb=   4.40°C on date= 5/ 1 at hour= 5
 DewPoint set equal to DryBulb
 Warning ** Dew Point=   4.70°C > Dry Bulb=   3.80°C on date= 5/ 1 at hour= 6
 DewPoint set equal to DryBulb
 Warning ** Suspected Blank line after processing        365  days
 ** Remaining records, if any, will be ignored
 Warning ** Missing Data Found on Source Weather Data File
 ** Missing (and corrected) Aerosol Optical Depth, Number of items= 8760
 Warning ** Out of Range Data Found on Weather Data File
 ** Out of Range Dew Point Temperatures > Dry Bulb Temperatures, Number of items=    3

 - Start Date/End Date for Weather Source
 Start Date=Jan  1; End Date=Dec 31

 - Actual Data Years for Monthly Data**
            Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec
             1966   1980   1964   1964   1968   1970   1977   1981   1979   1969   1974   1960
 - ** Not all weather data sources represent contiguous years.
 - ** Monthly data values may come from different years.

 - Data Sources should be checked for relevancy to these statistics.

 Average Delta DB Change=  0.76°C ; Std Dev=  0.73°C
 Average Delta DP Change=  0.62°C ; Std Dev=  0.69°C
 Average Delta Relative Humidity Change=  3.50% ; Std Dev=  3.63%
 Average Delta Wind Speed Change=  0.93m/s ; Std Dev=  0.88m/s
 Hourly Dry Bulb temperature change trigger = minimum of  11.07°C  and  10.°C
     11.07°C = calculated trigger based on mean change in dry-bulb temperature and standard deviation
shown above
     10.°C = trigger set by user

 -Output File Type=epw, with FileName=D:\DevTests\Release\WeatherData\Out\CAN_Ottawa-
International_Airport_CWEC.epw
 -Output File Type=csv, with FileName=D:\DevTests\Release\WeatherData\Out\CAN_Ottawa-
International_Airport_CWEC.csv
 -WMO Station 716280
```

Statistical Report File

As will be seen in comparison with a "statistical" report shown following, the audit file may contain some details about the data that the statistical report does not (such as the data years for the weather data). Some basic statistics are shown first:

```
Statistics for AUS_Sydney_IWEC-V1
 Location -- SYDNEY AUS
     {S 33° 57'} {E 151° 10'} {GMT +10.0 Hours}
 Elevation --    3m above sea level
 Standard Pressure at Elevation -- 101289Pa
 Data Source -- IWEC Data

 WMO Station 947670

 - Using Design Conditions from "World Climate Design Data 2001 ASHRAE Handbook"

 - If the design condition source is ASHRAE, the design conditions are carefully generated
 - from a period of record (typically 30 years) to be representative of that location and
 - be suitable for use in heating/cooling load calculations. If the source is not ASHRAE,
 - please consult the referenced source for the reasoning behind the data.

    Design Stat    HDB 99.6%       HDB 99%X WS 1%X WS 2.5%    X WS 5%CM WS .4%    CM MDB .4%    CM
WS 1%      CM MDB 1%    MWS 99.6%     PWD 99.6%     MWS .4%PWD .4%X MnDB Max    X MnDB Min    X
StdDB Max  X StdDB Min
    Units  {°C}    {°C}    {m/s}   {m/s}   {m/s}   {m/s}   {°C}    {m/s}   {°C}    {m/s}   {Degree}
    {m/s}  {Degree}     {°C}    {°C}    {°C}    {°C}
    HEATING 5.8     6.8     11.3    9.9     8.8     11.1    14.2    9.1     13.4    1.1     320     5.3     300
    39.3    3.1     2.9     1.9

    Design Stat    CDB .4%C MWB .4%    CDB 1% C MWB 1%    CDB 2% C MWB 2%    E WB .4%    E
MDB .4%    E WB 1%E MDB 1%    E WB 2%E MDB 2%    DP .4% HR .4% MDB .4%DP 1%   HR 1%   MDB 1% DP
2%   HR 2%   MDB 2% DB Range
    Units  {°C}    {°C}    {°C}    {°C}    {°C}    {°C}    {°C}    {°C}    {°C}    {°C}    {°C}    {°C}    {°C}
    {g/kg} {°C}    {°C}    {g/kg} {°C}    {°C}    {g/kg} {°C}    {°C}
    COOLING 32.2    20      29.5    19.7    27.9    20.1    23      28      22.3    26.2    21.7    25.3    21.7
    16.4    24.8    21.1    15.8    24.3    20.6    15.3    23.9    6.7
```

Or, if the weather converter must calculate the design stats:

```
Statistics for SAU_Jiddah
 Location -- JEDDAH_ 1980
     {N 21° 30'} {E  39° 12'} {GMT +3.0 Hours}
 Elevation --    0m above sea level
 Standard Pressure at Elevation -- 101325Pa


 WMO Station *unknown*

 - Using Design Conditions calculated from this weather file.

 -  The following design temperature statistics are calculated based on THIS weather file ONLY
 - and may not be representative of a long-term  period of record normally used for
 - design temperatures. Also, note that dew point temperatures are listed where
 - wet-bulb temperatures are normally presented.

    Design Stat    HDB 99.6%       HDB 99%
      Units        {C}           {C}
      HEATING      16.0    17.1

    Design Stat    CDB .4% CDB 1% CDB 2% CDP .4% CDP 1% CDP 2%
      Units        {C}     {C}    {C}    {C}     {C}    {C}
      COOLING      40.1    40.1   39.0   27.6    27.2   26.6
```

These are followed by groupings of Monthly data.

```
- Monthly Statistics for Dry Bulb temperatures °C
            Jan  Feb   Mar   Apr   May   Jun   Jul   Aug   Sep   Oct   Nov   Dec
Maximum    41.4  34.4  30.0  27.0  26.4  22.7  26.0  25.7  28.3  35.0  36.0  37.3
 Day:Hour  8:05  4:05 16:03 28:02  6:05  8:05 24:03 14:05 30:02  9:03 20:04 26:05

Minimum    15.0  10.2  13.0   8.8   6.7   5.0   3.9   3.8   7.6   8.6   9.6  13.0
 Day:Hour 13:20 18:18 20:19 11:20 17:20 22:20  6:20  8:20 10:20 10:20  2:20 15:19

Daily Avg  23.0  22.6  20.6  18.7  15.8  13.0  12.3  13.6  15.3  18.1  19.7  21.2

   - Maximum Dry Bulb temperature of  41.4°C on Jan  8
   - Minimum Dry Bulb temperature of   3.8°C on Aug  8
```

For the dry-bulb temperatures, an average hourly report, by month, is also given:

```
- Average Hourly Statistics for Dry Bulb temperatures °C
            Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep   Oct   Nov   Dec
 0:01- 1:00  7.0  10.0   9.1   9.9  10.9  12.1  12.9  13.2  13.9  12.9  10.8   7.8
 1:01- 2:00  6.5   9.5   8.9   9.7  10.7  12.0  12.9  13.1  13.6  12.6  10.4   7.7
 2:01- 3:00  6.0   9.1   8.7   9.5  10.5  11.9  12.8  12.9  13.3  12.4  10.1   7.7
 3:01- 4:00  6.0   8.6   8.4   9.2  10.5  11.7  12.8  12.6  13.1  12.2   9.7   7.4
 4:01- 5:00  5.7   8.5   8.1   8.9  10.2  12.2  13.3  12.6  13.1  12.3   9.7   7.3
 5:01- 6:00  5.4   8.4   7.9   8.9  10.6  12.7  13.8  12.6  13.3  12.4   9.7   7.1
 6:01- 7:00  5.3   8.3   8.4  10.6  12.3  13.2  14.3  14.0  14.2  12.5   9.7   7.1
 7:01- 8:00  6.0   9.2   9.9  12.1  13.8  14.6  15.7  15.7  15.9  13.8  10.9   7.3
 8:01- 9:00  7.6  10.1  11.2  13.1  15.1  15.9  17.1  17.0  17.5  15.1  12.1   8.5
 9:01-10:00  8.9  11.0  11.8  14.0  16.2  17.2  18.4  18.3  18.7  16.4  13.4   9.3
10:01-11:00  9.8  12.1  12.6  14.9  17.4  17.7  19.3  20.0  20.3  17.5  14.1  10.2
11:01-12:00 10.7  13.2  13.3  15.6  18.5  18.2  20.2  20.9  21.5  18.5  14.8  10.8
12:01-13:00 11.4  14.2  13.9  16.0  18.7  18.7  21.0  21.2  21.8  19.6  15.4  11.3
13:01-14:00 12.0  14.5  14.1  15.9  18.5  18.4  20.5  21.0  21.4  19.2  15.3  11.7
14:01-15:00 12.1  14.8  14.0  15.6  17.9  18.1  20.1  20.1  21.0  18.8  15.1  12.0
15:01-16:00 12.2  15.1  13.6  15.1  16.9  17.8  19.6  19.1  20.3  18.3  14.9  11.7
16:01-17:00 11.4  14.1  12.9  14.3  16.0  16.6  18.3  18.5  18.8  17.2  14.4  10.7
17:01-18:00 10.4  13.1  11.8  13.2  14.7  15.5  17.0  17.2  17.3  16.0  13.8  10.4
18:01-19:00 10.0  12.2  10.9  12.4  13.4  14.4  15.7  15.6  16.1  14.8  13.2  10.0
19:01-20:00  9.4  11.8  10.5  11.8  12.4  13.8  15.1  14.8  15.7  14.5  12.8   9.6
20:01-21:00  9.2  11.4  10.2  11.2  12.0  13.3  14.5  14.4  15.3  14.1  12.3   9.2
21:01-22:00  8.6  11.0   9.9  11.0  11.6  12.8  13.8  14.1  15.0  13.7  11.9   8.9
22:01-23:00  8.4  10.7   9.7  10.6  11.4  12.6  13.5  13.9  14.7  13.4  11.5   8.5
23:01-24:00  7.6  10.3   9.4  10.3  11.0  12.4  13.2  13.6  14.2  13.1  11.1   8.1
 Max Hour    16    16    14    13    13    13    13    13    13    13    13    15
 Min Hour     7     7     6     5     5     4     4     5     4     4     5     7
```

This is followed by the remainder of the monthly displays:

```
- Monthly Statistics for Dew Point temperatures °C
            Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep   Oct   Nov   Dec
Maximum     6.7   3.6   6.4   7.6   9.6   9.3  10.3  11.4  12.2  10.6   7.3  -2.1
 Day:Hour 31:24 28:24 31:24 30:24 31:24 30:24 31:24 31:24 30:24 31:24 30:24 31:24

Minimum    -1.1   4.1  -1.7   3.3   3.9   8.8   9.2  10.3   5.6   9.1   1.7  -6.7
 Day:Hour  2:03  2:03  4:06  3:24  6:05  1:01  1:01  1:01 15:05  2:23 20:01 24:02

Daily Avg   4.4   6.8   5.4   6.8   8.7   9.7  10.5  11.2  11.1   9.7   7.5   5.1

   - Maximum Dew Point temperature of  12.2°C on Sep 30
   - Minimum Dew Point temperature of  -6.7°C on Dec 24
```

```
 - Monthly Statistics for Wind Chill/Heat Index temperatures °C **
            Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec
Minimum WC   -1     -1     -6     -1     -2      4                          9      0     -8
 Day:Hour 19:09   2:10  16:06  15:04   5:24   1:23                      27:04  27:04  28:04

Average WC    6      7      4      5      5      6                          9      7      4
Avg Del WC    1      2      5      3      4      4                          0      2      3
 # Hours WC 293    166    258    159     56     10                          3     86    358

Maximum HI                                            27     28
 Day:Hour                                           2:10  15:11

Average HI                                           27     28
Avg Del HI                                            0      0
 # Hours HI                                           1      1

  - **WindChill/HeatIndex Temps -- statistics...only those different from Air Temps

 - Monthly Statistics for Extreme temperatures °C
  #Days     Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec
Max >= 32                                             1             1
Max <=  0
Min <=  0          1                                                                     1
Min <=-18

 - Monthly Heating/Cooling Degree Days/Hours
            Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec
HDD base
10C          52      3      7      1      0      0      0      0      0      0      1     36
18C         290    188    223    173    130    100     73     59     54     92    169    273

CDD base
10C          10     39     32     68    118    142    188    189    200    157     72     10
18C           0      0      0      0      0      3     14      0     14      1      0      0

20C           0      9      0     45     93    136    330    223    410    129      0      0
23C           0      0      0      5     13     41    167     50    169     13      0      0
27C           0      0      0      0      0      0     61      5     59      0      0      0

    - 1227 annual cooling degree-days (10°C baseline)
    -  100 annual heating degree-days (10°C baseline)

    -   32 annual cooling degree-days (18°C baseline)
    - 1825 annual heating degree-days (18°C baseline)
```

```
 - Monthly Average Daily Relative Humidity %
            Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec
     4am     87     84     78     82     87     85     83     87     85     83     83     85
    10am     77     79     68     65     64     64     62     67     65     70     70     79
     3pm     61     63     58     60     56     60     56     57     56     58     62     67
    10pm     79     76     76     76     83     80     80     83     79     78     77     79

Maximum     100     96     96    100    100     96     93     96    100     96     96    100
 Day:Hour  7:05   6:04  20:22   9:03  25:02   5:01  18:04   7:02   4:07   7:07  11:07   7:05

Minimum      23     30     22     24     25     30     25     36     19     20     32     25
 Day:Hour 17:15  14:13   4:16   5:10   9:12  17:10   2:13  14:13  28:15  30:13  20:15  24:15

 - Monthly Indicators for Precipitation/Moisture (kPa)
            Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec
            0.8    1.1    0.9    1.0    1.1    1.2    1.3    1.3    1.3    1.2    1.1    0.9
```

```
 - Monthly Statistics for Solar Wh/m²
            Jan     Feb     Mar     Apr     May     Jun     Jul     Aug     Sep     Oct     Nov     Dec
Direct Avg  3056    3829    4638    5599    6278    6541    7661    6916    6357    4809    3192    2941
Direct Max  7117    7987    9343   10197   10799    9981   10792   10622    9335    8010    7011    7019
     Day      20      18      19      27      11       6       4       1      16      12      20      31

Diffuse Avg  965    1300    1529    1994    2246    2329    1966    1756    1534    1352    1090     858

    - Maximum Direct Solar of 10799 Wh/m² on May 11
```

```
 - Monthly Average Daily Wind Direction ° {N=0 or 360,E=90,S=180,W=270}
            Jan     Feb     Mar     Apr     May     Jun     Jul     Aug     Sep     Oct     Nov     Dec
            151     203     210     247     261     269     275     262     243     216     161     159

 - Monthly Statistics for Wind Speed m/s
            Jan     Feb     Mar     Apr     May     Jun     Jul     Aug     Sep     Oct     Nov     Dec
Maximum      2.1     5.6    12.4     5.1     4.8     3.9     4.1     3.9     2.4     2.4     0.4    13.4
 Day:Hour  31:24   28:24   31:16   30:24   31:24   30:24   31:24   31:24   30:24   31:24   30:24   27:13

Minimum      0.0     1.5     2.6     2.1     4.7     5.0     4.0     4.0     3.3     2.2     2.2     2.1
 Day:Hour   2:04    1:01    4:05    3:24    1:01    1:01    1:01    1:01    1:01    1:01    1:01   26:05

Daily Avg    2.5     3.5     5.1     4.8     6.5     5.6     5.7     5.5     4.8     3.9     2.7     3.6

    - Maximum Wind Speed of  13.4 m/s on Dec 27
    - Minimum Wind Speed of   0.0 m/s on Jan  2
```

```
 - Monthly Calculated "undisturbed" Ground Temperatures °C
            Jan     Feb     Mar     Apr     May     Jun     Jul     Aug     Sep     Oct     Nov     Dec
  0.5 m     9.8     9.5    10.1    11.5    13.4    15.1    16.3    16.7    16.0    14.6    12.8    11.0
  2.0 m    11.0    10.4    10.6    11.4    12.6    14.0    15.1    15.7    15.6    14.8    13.5    12.1
  4.0 m    12.0    11.4    11.3    11.6    12.4    13.3    14.2    14.8    14.9    14.5    13.8    12.8
```

And then the Köppen and typical/extreme period calculations:

```
- Climate type "Cfa" (Köppen classification)
- Humid subtropical (mild with no dry season, hot summer, lat. 20-35°S)
- Unbearably humid periods in summer, but passive cooling is possible

- Typical/Extreme Period Determination
- Summer is Nov:Jan
    Extreme Summer Week (nearest maximum temperature for summer)
    Extreme Hot Week Period selected: Jan  4:Jan 10, Maximum Temp=  41.40°C, Deviation=|15.329|°C
    Typical Summer Week (nearest average temperature for summer)
    Typical Week Period selected: Nov 29:Dec  5, Average Temp=  21.32°C, Deviation=| 0.000|°C
- Winter is May:Jul
    Extreme Winter Week (nearest minimum temperature for winter)
    Extreme Cold Week Period selected: Jul  3:Jul  9, Minimum Temp=   3.90°C, Deviation=| 7.294|°C
    Typical Winter Week (nearest average temperature for winter)
    Typical Week Period selected: Jun  5:Jun 11, Average Temp=  13.73°C, Deviation=| 0.060|°C
- Autumn is Feb:Apr
    Typical Autumn Week (nearest average temperature for autumn)
    Typical Week Period selected: Mar 22:Mar 28, Average Temp=  20.61°C, Deviation=| 0.083|°C
- Spring is Aug:Oct
    Typical Spring Week (nearest average temperature for spring)
    Typical Week Period selected: Aug  1:Aug  7, Average Temp=  15.68°C, Deviation=| 0.392|°C
```

As this data is all tab-delimited, putting in a spreadsheet and displaying is not difficult:

```
- Monthly Statistics for Dry Bulb temperatures °C
                Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec
   Daily Avg    10.7   9.6    11.4   15.1   19.7   24.6   27.3   27.2   23.7   19.1   14.5   11.2
   Maximum      17     17     18.8   25     33.4   35.8   35     36     34     28     22.2   19.2
   Minimum      3.6    2.8    4      4.6    9      14.6   20.4   20     15     12     5.9    1
- Maximum Dry Bulb temperature of  36.0°C on Aug  1
- Minimum Dry Bulb temperature of   1.0°C on Dec 12
```

And these can be easily used to produce graphs:

Daily Dry Bulb Statistics
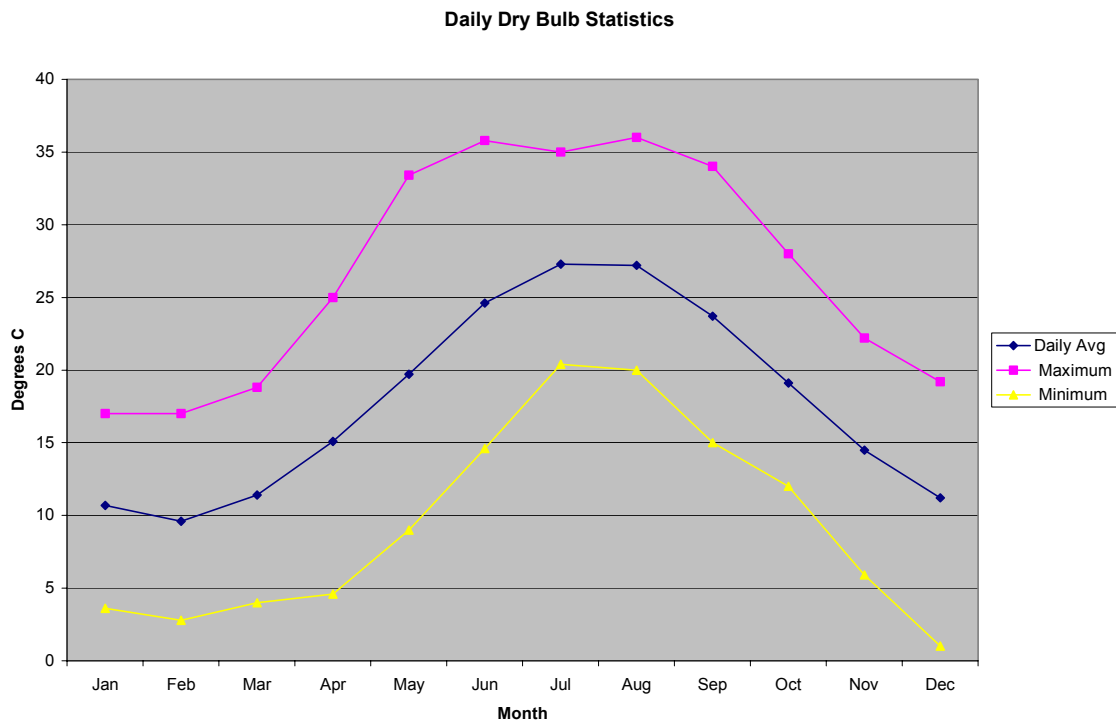
Figure 4. Graph of Spreadsheet Data

Design Day Calculations Output

Using the WMO field (or determining it from the WBAN field), the Weather Converter performs table look up in the Design Condition files to see if there are recorded design conditions for the subject location. If this location is found, then design day objects are produced on the resultant design day object (ddy extension) file – ready for inclusion into an EnergyPlus input data file. If no design conditions are located, then the design day object file will still include a location object for inclusion with EnergyPlus. However, statistics using the weather file are now displayed to the statistics file – these "can" be used to create your own design day definitions but you should read the warning that is issued and take care if your weather file is only a "single instance" weather data representation.

The location objects as well as the design condition objects are constrained by the data source. Some data sources do not have elevation information – thus, a location object from such a source will have an elevation of 0.0. Likewise, the time zone of some locations may not be available from the source data nor other data resources that the weather converter

uses. A time zone will be estimated from the standard meridian of the location (determined by the longitude) but it may not be accurate. A user needs to be aware of these limitations when taking the design day files from the weather converter.

An excerpt of a design day output is shown in the following (actual design day objects have been deleted for brevity):

```
! The following Location and Design Day data are produced as possible from the weather data source.
 ! No special attempts at re-creating or determining missing data parts (e.g. Wind speed or direction)
 ! are done.  Therefore, you should look at the data and fill in any incorrect values as you desire.

 Location,
  Ottawa Int'l_ON_CAN WYEC2-B-04772,     !- Location Name
   45.32000    ,        !- Latitude {N+ S-}
  -75.67000    ,        !- Longitude {W- E+}
  -5.000000    ,        !- Time Zone Relative to GMT {GMT+/-}
   114.0000    ;        !- Elevation {m}

! Using Design Conditions from "Canada Climate Design Data 2001 ASHRAE Handbook"

! Ottawa Int'l_ON_CAN Heating 99.6%, MaxDB= -24.80 Wind Speed=   3.90 Wind Dir= 290.00

! Ottawa Int'l_ON_CAN Heating 99%, MaxDB= -22.20 Wind Speed=   4.50 Wind Dir= 250.00

! Ottawa Int'l_ON_CAN Cooling (DB=>MWB) .4%, MaxDB=  30.10 MWB=  21.30

! Ottawa Int'l_ON_CAN Cooling (DB=>MWB) 1%, MaxDB=  28.50 MWB=  20.50

! Ottawa Int'l_ON_CAN Cooling (DB=>MWB) 2%, MaxDB=  26.80 MWB=  19.50

! Ottawa Int'l_ON_CAN Cooling (WB=>MDB) .4%, MDB=  28.00 WB=  22.80

! Ottawa Int'l_ON_CAN Cooling (WB=>MDB) 1%, MDB=  26.40 WB=  21.80

! Ottawa Int'l_ON_CAN Cooling (WB=>MDB) 2%, MDB=  25.30 WB=  20.80

! Ottawa Int'l_ON_CAN Cooling (DP=>MDB) .4%, MDB=  25.50 DP=  21.10 HR=   0.02

! Ottawa Int'l_ON_CAN Cooling (DP=>MDB) 1%, MDB=  24.60 DP=  20.20 HR=   0.02

! Ottawa Int'l_ON_CAN Cooling (DP=>MDB) 2%, MDB=  23.70 DP=  19.20 HR=   0.01
```

Design day "definitions" originate in the ASHRAE Handbook of Fundamentals. Prior to 1997, these conditions were described for winter and summer (heating and cooling). They were based on seasonal percentages.

Beginning in 1997, and continuing (the latest version was published in 2001), the design condition data is based on annual percentages. In addition, only locations with long-term hourly observations data (on which to form the basis) are included.

[From ASHRAE Handbook of Fundamentals, 2001]:

■ Heating conditions are often used in the sizing of heating equipment. In cold spells, dry-bulb temperatures below the design conditions can last for a week or more.

■ The first cooling conditions, based on dry-bulb temperatures (i.e., DB=>MWB), often represent conditions on hot, mostly sunny days. These are useful for cooling applications, especially air-conditioning.

■ Design conditions based on wet-bulb temperatures (i.e., WB=>MDB) represent extremes of the total sensible plus latent heat of outdoor air. This information is useful for cooling towers, evaporative coolers, and fresh air ventilation system design.

■ Design conditions based on dew-point temperatures (i.e., DP=>MDB) are directly related to extremes of humidity ratio, which represent peak moisture loads from the weather. Extreme dew-point conditions may occur on days with moderate dry-bulb temperatures resulting in relatively high humidity. These values are especially useful for applications

involving humidity control, such as desiccant cooling and dehumidification, cooling-based dehumidification, and fresh air ventilation systems. These values are also used as a checkpoint when analyzing the behavior of cooling systems at part load conditions, particularly when such systems are used for humidity control as a secondary function.

Köppen Climate Classification

Various attempts have been made to classify the climates of the earth into climatic regions. One notable, yet ancient and misguided example is that of Aristotle's Temperate, Torrid, and Frigid Zones. However, the 20th century classification developed by German climatologist and amateur botanist Wladimir Köppen (1846-1940) continues to be the authoritative map of the world climates in use today.

Introduced in 1928 as a wall map co-authored with student Rudolph Geiger, the Köppen system of classification (map) was updated and modified by Köppen until his death. Since that time, it has been modified by several geographers.

The modified Köppen Climate Classification System is the most widely used system for classifying the world's climates. Its categories are based on the annual and monthly averages of temperature and precipitation. The Köppen system recognizes six major climatic types; each type is designated by a capital letter.

In addition to the major climate types, each category is further sub-divided into sub-categories based on temperature and precipitation. There are only 24 sub-categories possible – making the general schemes quite easy to comprehend.

For example, the U.S. states located along the Gulf of Mexico are designated as "Cfa." The "C" represents the "mild mid-latitude" category, the second letter "f" stands for the German word *feucht* or "moist," and the third letter "a" indicates that the average temperature of the warmest month is above 22°C. Thus, "Cfa" gives us a good indication of the climate of this region, a mild mid-latitude climate with no dry season and a hot summer.

The Köppen classification code (and some statistics) was adapted (with permission of Peter Schild) from the COMIS weather program code.

Table 4. Köppen Climate Classification -- Major Groups

Köppen Climate Type	Description
A	Tropical Moist Climates: all months have average temperatures above 18 degrees Celsius
B	Dry Climates: with deficient precipitation during most of the year
C	Moist Mid-latitude Climates with Mild Winters
D	Moist Mid-Latitude Climates with Cold Winters
E	Polar Climates: with extremely cold winters and summers
H	Highland areas: Due to mountainous areas, this classification can encompass any of the previous five.

More details on each of the major categories and sub-categories follow:

Tropical Moist Climates (A)

Tropical moist climates extend northward and southward from the equator to about 15 to 25 degrees of latitude. In these climates all months have average temperatures greater than 18 degrees Celsius. Annual precipitation is greater than 1500 mm. Three minor Köppen climate types exist in the A group and their designation is based on seasonal distribution of rainfall.

Af or tropical wet is a tropical the climate where precipitation occurs all year long. Monthly temperature variations in this climate are less than 3 degrees Celsius. Because of intense surface heating and high humidity cumulus and cumulonimbus clouds form early in the afternoons almost every day. Daily highs are about 32 degrees Celsius while night time temperatures average 22 degrees Celsius. **Am** is a tropical monsoon climate. Annual rainfall is equal to or greater than **Af**, but falls in the 7 to 9 hottest months. During the dry season very little rainfall occurs. The tropical wet and dry or savanna (**Aw**) has an extended dry season during winter. Precipitation during the wet season is usually less than 1000 millimeters and only during the summer season.

Dry Climates (B)

The most obvious climatic feature of these climates is potential evaporation and transpiration exceeds precipitation. These climates extend from 20 - 35 degrees North and South of the equator and in large continental regions of the mid-latitudes often surrounded by mountains. Minor types of this climate include: **Bw** - dry arid (desert) is a true desert climate. It covers 12 % of the earth's land surface and is dominated by xerophytic vegetation. **Bs** - dry semiarid (steppe) is a grassland climate that covers 14% of the earth's land surface. It receives more precipitation than the **Bw** either from the inter-tropical convergence zone or from mid-latitude cyclones.

Moist Subtropical Mid-Latitude Climates (C)

This climate generally has warm and humid summers with mild winters. Its extent is from 30 to 50 degrees of latitude mainly on the eastern and western borders of most continents. During the winter the main weather feature is the mid-latitude cyclone. Convective thunderstorms dominate summer months. Three minor types exist: **Cfa** - humid subtropical; **Cs** - mediterranean; and **Cfb** - marine. The humid subtropical climate (**Cfa**) has hot muggy summers and mainly thunderstorms. Winters are mild and precipitation during this season comes from mid-latitude cyclones. A good example of a **Cfa** climate is the southeastern USA. **Cfb**, marine, climates are found on the western coasts of continents. They have a humid climate with short dry summer. Heavy precipitation occurs during the mild winters because of continuous presence of mid-latitude cyclones. Mediterranean climates (**Cs**) receive rain primarily during winter season from the mid-latitude cyclone. Extreme summer aridity is caused by the sinking air of the subtropical highs and may exist for up to 5 months. Locations in North America are from Portland, Oregon to all of California.

Moist Continental Mid-latitude Climates (D)

Moist continental mid-latitude climates have warm to cool summers and cold winters. The location of these climates is pole ward of the C climates. The warmest month is greater than 10º C, while the coldest month is less than -30º C. Winters are severe with snowstorms, strong winds, bitter cold from Continental Polar or Arctic air masses. Like the C climates there are three minor types: **Dw** - dry winters; **Ds** - dry summers; and **Df** - wet all seasons.

Polar Climates (E)

Polar climates have year-round cold temperatures with warmest month less than 10º C. Polar climates are found on the northern coastal areas of North America and Europe, Asia and on the landmasses of Greenland and Antarctica. Two minor climate types exist. **ET** or polar tundra is a climate where the soil is permanently frozen to depths of hundreds of meters, a condition known as permafrost. Vegetation is dominated by mosses, lichens, dwarf trees and scattered woody shrubs. **EF** or polar ice caps has a surface that is permanently covered with snow and ice.

Highlands Areas (H)

Highland areas can encompass any of the previously mentioned major categories –- the determining factor is one of altitude (temperature decreases roughly 2º C for every increase of 305 m). This is a complex climate zone. Highland regions roughly correspond to the major categories change in temperature with latitude – with one important exception. Seasons only exist in highlands if they also exist in the nearby lowland regions. For example, although **A** climates have cooler temperatures at higher elevations, the seasonal changes of **C**, **D** and **E** climates are not present.

The following will give you an overview of the world and its Köppen classifications.
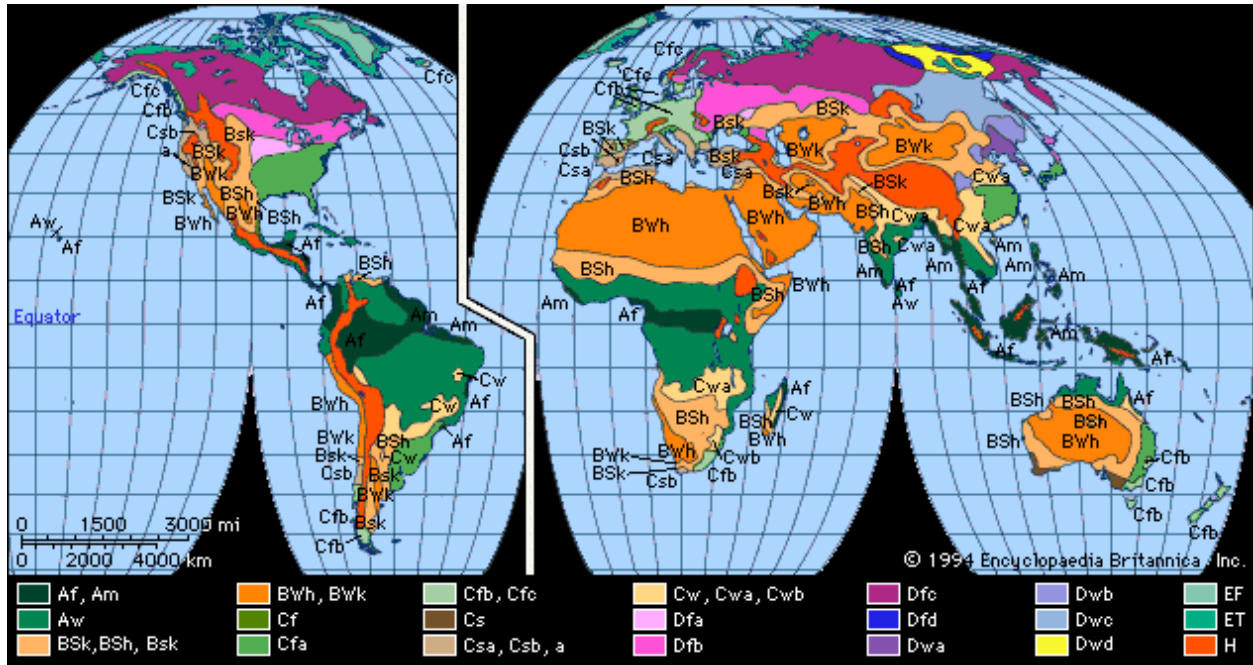
Figure 5. World viewed as Köppen Climate Zones

And a more basic view with monthly dry bulb temperature and dew point temperatures for these zones (Northern Hemisphere).
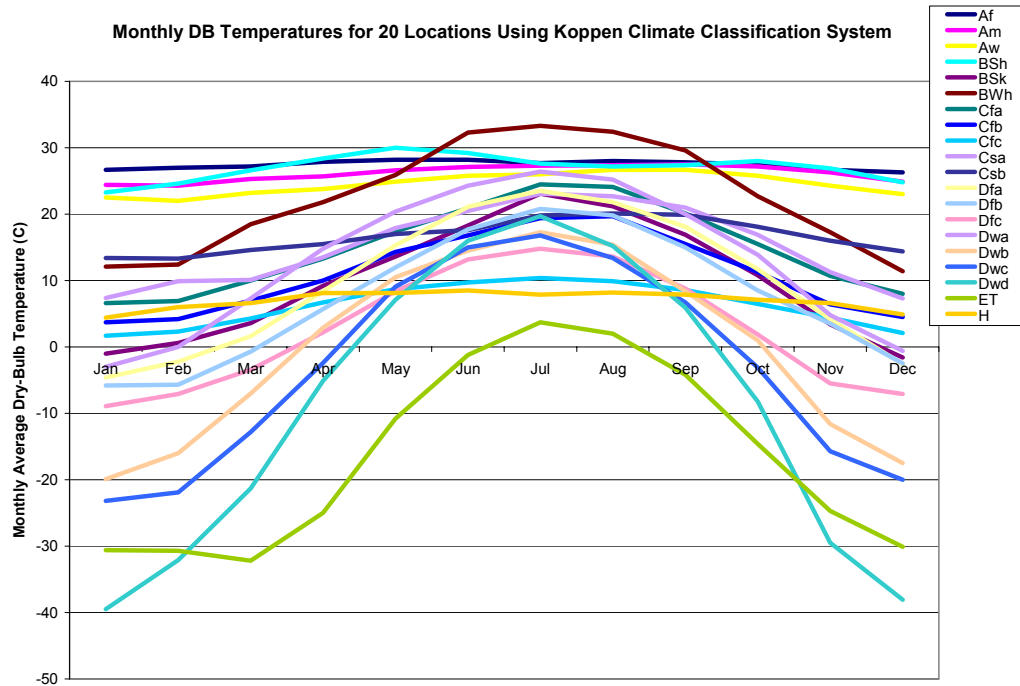
Figure 6. Monthly Dry Bulb Temperatures in Köppen Climates (Northern Hemisphere)
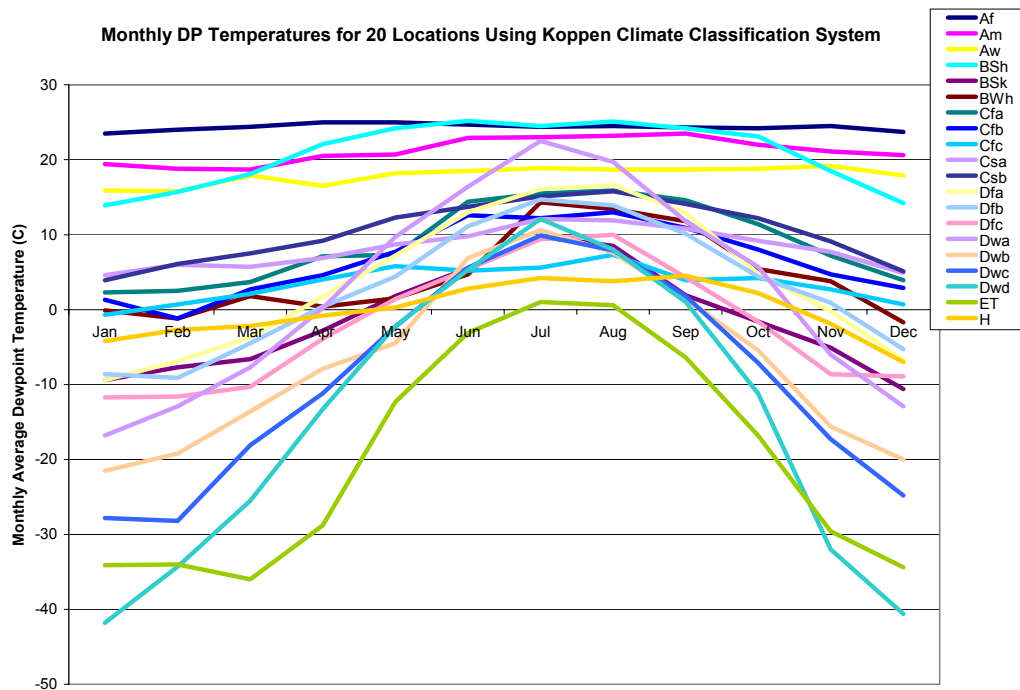
Figure 7. Monthly Dew Point in Köppen Climates (Northern Hemisphere)

EnergyPlus Weather File (EPW) Data Dictionary

The "data dictionary" for EnergyPlus Weather Data is shown below. Note that semi-colons do NOT terminate lines in the EnergyPlus Weather Data.

Note that in the header records where "date" is used, the interpretation is shown in the following table.

Table 5. Weather File Date Field Interpretation

Field Contents	Interpretation	Header Applicability
<number>	Julian Day of Year	All date fields
<number> / <number>	Month / Day	All date fields
<number> Month	Day and Month	All date fields
Month <number>	Day and Month	All date fields
<number> Weekday in Month	Numbered weekday of month	Holiday, DaylightSavingPeriod
Last Weekday In Month	Last weekday of month	Holiday, DaylightSavingPeriod

In the table, Month can be one of (January, February, March, April, May, June, July, August, September, October, November, December). Abbreviations of the first three characters are also valid.

In the table, Weekday can be one of (Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday). Abbreviations of the first three characters are also valid.

```
!ESP(r)/EnergyPlus Weather Format
!April 2002
\memo  Dates in the EPW file can be several formats:
\memo  <number>/<number>  (month/day)
\memo  <number> Month
\memo  Month <number>
\memo <number>  (taken to be Julian day of year)
\memo Months are January, February, March, April, May,
\memo          June, July, August, September, October, November, December
\memo Months can be the first 3 letters of the month
```

```
LOCATION,
  A1, \field city
  \type alpha
  A2, \field State Province Region
  \type alpha
  A3, \field Country
  \type alpha
  A4, \field Source
  \type alpha
  N1, \field WMO
   \note usually a 6 digit field.  Used as alpha in EnergyPlus
   \type alpha
  N2 , \field Latitude
      \units deg
      \minimum -90.0
      \maximum +90.0
      \default 0.0
      \note + is North, - is South, degree minutes represented in decimal (i.e. 30 minutes is .5)
      \type real
  N3 , \field Longitude
      \units deg
      \minimum -180.0
      \maximum +180.0
      \default 0.0
      \note - is West, + is East, degree minutes represented in decimal (i.e. 30 minutes is .5)
      \type real
  N4 , \field TimeZone
      \units hr - not on standard units list???
      \minimum -12.0
      \maximum +12.0
      \default 0.0
      \note  Time relative to GMT.
      \type real
  N5 ; \field Elevation
      \units m
      \minimum -1000.0
      \maximum< +9999.9
      \default 0.0
      \type real
```

The Location header record duplicates the information required for the Location Object. When only a Run Period object is used (i.e. a weather file), then the Location Object Is not needed. When a Run Period and Design Day objects are entered, then the Location on the weather file (as described previously) is used and overrides any Location Object entry.

```
DESIGN CONDITIONS,
    N1, \field Number of Design Conditions
    A1, \field Design Condition Source
        \note current sources are ASHRAE HOF 2001 US Design Conditions, Canadian Design Conditions
        \note and World Design Conditions
    A2, \field Design Condition Type (HEATING)
      \note fields here will be dependent on the source, they are shown in a header/data format
      \note in both the .rpt and .csv files that are produced by the WeatherConverter program
    ...
    An, \field Design Condition Type (COOLING)
      \note same as note on Heating Design Conditions
```

The Design Conditions header record encapsulates matching (using WMO# -- World Meteorological Organization Station Number) design conditions for a weather file location. Currently only those design conditions contained in the ASHRAE Handbook of Fundamentals 2001 are contained in the weather files. These conditions can be used as desired. In addition, Design Day definition files have been created of all World, Canada, and United States Design Conditions. These files are available in the DataSet folder of the EnergyPlus installation.

```
TYPICAL/EXTREME PERIODS,
     N1, \field Number of Typical/Extreme Periods
     A1, \field Typical/Extreme Period 1 Name
     A2, \field Typical/Extreme Period 1 Type
     A3, \field Period 1 Start Day
     A4, \field Period 1 End Day
     \note repeat (A1-A3) until number of typical periods
 -- etc to # of periods entered
```

Using a heuristic method, the weather converter can determine typical and extreme weather periods for full year weather files. These will then be shown on the Typical/Extreme Periods header record. These are also reported in the statistical report output from the Weather Converter.

```
GROUND TEMPERATURES,
     N1, Number of Ground Temperature Depths
     N2, \field Ground Temperature Depth 1
       \units m
     N3, \field Depth 1 Soil Conductivity
       \units W/m-K,
     N4, \field Depth 1 Soil Density
       \units kg/m3
     N5, \field Depth 1 Soil Specific Heat
       \units J/kg-K,
     N6, \field Depth 1 January Average Ground Temperature
      \units C
     N7, \field Depth 1 February Average Ground Temperature
      \units C
     N8, \field Depth 1 March Average Ground Temperature
      \units C
     N9, \field Depth 1 April Average Ground Temperature
      \units C
     N10, \field Depth 1 May Average Ground Temperature
      \units C
     N11, \field Depth 1 June Average Ground Temperature
      \units C
     N12, \field Depth 1 July Average Ground Temperature
      \units C
     N13, \field Depth 1 August Average Ground Temperature
      \units C
     N14, \field Depth 1 September Average Ground Temperature
      \units C
     N15, \field Depth 1 October Average Ground Temperature
      \units C
     N16, \field Depth 1 November Average Ground Temperature
      \units C
     N17, \field Depth 1 December Average Ground Temperature
      \units C
     \note repeat above (N2-N17) to number of ground temp depths indicated
 -- etc to # of depths entered
```

The weather converter program can use a full year weather data file to calculate "undisturbed" ground temperatures based on temperatures. Since an important part of soil heat transfer includes soil properties such as conductivity, density and specific heat AND these cannot be calculated from simple weather observations, this header record is provided for user information. In addition, the ground temperatures used in EnergyPlus may be calculated via different methods – so no transfer of this header record data to EnergyPlus input currently exists.

```
HOLIDAYS/DAYLIGHT SAVING,
    A1, \field LeapYear Observed
     \type choice
     \key Yes
     \key No
     \note Yes if Leap Year will be observed for this file
     \note No if Leap Year days (29 Feb) should be ignored in this file
    A2, \field Daylight Saving Start Day
    A3, \field Daylight Saving End Day
    N1, \field Number of Holidays (essentially unlimited)
    A4, \field Holiday 1 Name
    A5, \field Holiday 1 Day
     \note repeat above two fields until Number of Holidays is reached
-- etc to # of Holidays entered
```

The Holidays / Daylight Saving header record details the start and end dates of Daylight Saving Time and other special days such as might be recorded for the weather file. These can be used by keying "Yes" for appropriate fields in the Run Period Object.

For example, using a RunPeriod:

```
RunPeriod,     ! Annual simulation
          5,           1,  ! Start Month , Day
          5,          10,  ! End Month, Day
           ,     ! Will use day as shown on Weatherfile
        Yes,    ! Will use Holidays as embedded within the weather file
         No;    ! Will use Daylight Saving Time as embedded within the weather file
```

Will use any holidays specified in the Holidays / Daylight Saving header record of the weather file but will not use the Daylight Saving Period that is specified there (if any). In addition, the user can specify Special Day Periods via the Special Day Period object and/or Daylight Saving Period via the Daylight Saving Period object to additionally specify these items.

```
COMMENTS 1, A1 \field Comments_1
COMMENTS 2, A1 \field Comments_2
```

The Comment header records may provide additional information about the weather data source or other information which may not fit in other header record formats.

```
DATA PERIODS,
    N1, \field Number of Data Periods
    N2, \field Number of Records per hour
    A1, \field Data Period 1 Name/Description
    A2, \field Data Period 1 Start Day of Week
       \type choice
       \key  Sunday
       \key  Monday
       \key  Tuesday
       \key  Wednesday
       \key  Thursday
       \key  Friday
       \key  Saturday
    A3, \field Data Period 1 Start Day
    A4, \field Data Period 1 End Day
       \note repeat above to number of data periods
-- etc to # of periods entered
```

A weather file may contain several "data periods" though this is not required (and, in fact, may be detrimental). In addition, a weather file may contain multiple records per hour BUT these must match the Number of Time Steps In Hour for the simulation. Multiple interval data files can be valued when you want to be sure of the weather values for each time step (rather than relying on "interpolated" weather data).

For those interested in creating their own weather data or reading the .csv and .epw files that are produced by the Weather Converter program, the fields are shown in the following "IDD" description. Items shown in bold are used directly in the EnergyPlus program.

```
! Actual data does not have a descriptor
    N1, \field Year
    N2, \field Month
    N3, \field Day
    N4, \field Hour
    N5, \field Minute
    A1, \field Data Source and Uncertainty Flags
    \memo Initial day of weather file is checked by EnergyPlus for validity (as shown below)
    \memo Each field is checked for "missing" as shown below.  Reasonable values or the last
    \memo "good" value is substituted.
    N6, \field Dry Bulb Temperature
        \units C
        \minimum> -70
        \maximum< 70
    N7, \field Dew Point Temperature
        \units C
        \minimum> -70
        \maximum< 70
    N8, \field Relative Humidity
        \missing 999.
        \minimum 0
        \maximum 110
    N9, \field Atmospheric Station Pressure
        \units Pa
        \missing 999999.
        \minimum> 31000
        \maximum< 120000
    N10, \field Extraterrestrial Horizontal Radiation
        \units Wh/m2
        \missing 9999.
    N11, \field Extraterrestrial Direct Normal Radiation
        \units Wh/m2
        \missing 9999.
    N12, \field Horizontal Infrared Radiation Intensity
        \units Wh/m2
        \missing 9999.
    N13, \field Global Horizontal Radiation (used only for Photovoltaic objects)
        \units Wh/m2
        \missing 9999.
    N14, \field Direct Normal Radiation
        \units Wh/m2
        \missing 9999.
        \minimum 0
    N15, \field Diffuse Horizontal Radiation
        \units Wh/m2
        \missing 9999.
        \minimum 0
    N16, \field Global Horizontal Illuminance
        \units lux
        \missing 999999.
        \note will be missing if >= 999900
    N17, \field Direct Normal Illuminance
        \units lux
        \missing 999999.
        \note will be missing if >= 999900
    N18, \field Diffuse Horizontal Illuminance
        \units lux
        \missing 999999.
        \note will be missing if >= 999900
    N19, \field Zenith Luminance
        \units Cd/m2
        \missing 9999.
        \note will be missing if >= 9999
```

```
       N20, \field Wind Direction
          \units degrees
          \missing 999.
          \minimum 0
          \maximum 360
       N21, \field Wind Speed
          \units m/s
          \missing 999.
          \minimum 0
          \maximum 40
       N22, \field Total Sky Cover (used if Horizontal IR Intensity missing)
          \missing 99
       N23, \field Opaque Sky Cover (used if Horizontal IR Intensity missing)
          \missing 99
       N24, \field Visibility
          \units km
          \missing 9999
       N25, \field Ceiling Height
          \units m
          \missing 99999
       N26, \field Present Weather Observation
       N27, \field Present Weather Codes
       N28, \field Precipitable Water
          \units mm
          \missing 999
       N29, \field Aerosol Optical Depth
          \units thousandths
          \missing .999
       N30, \field Snow Depth
          \units cm
          \missing 999
       N31; \field Days Since Last Snowfall
          \missing 99
```

CSV Format (In/Out)

For the "header" records in the CSV file, they are basically the same as the header records for the EPW file (see above). However, in the CSV file, each header is shown and then the data. Partial year files will not have all of these headers "filled" in.

Location Header/Data (CSV)

```
Location Title,Latitude {N+/S-},Longitude {E+/W-},TimeZone {+/- GMT},Elevation {m}
LOCATION_SYDNEY__AUS_IWEC Data_947670,-33.95,151.18,10.0,3.0
```

LOCATION + the city, state/province, country and WMO fields from the EPW file are concatenated to form the "Location Title". The latitude, longitude, time zone and elevation fields are numeric.

Design Conditions Header/Data (CSV)

If there are design conditions, then the format is as follows:

```
Number of Design Conditions,Title of Design Condition,Design Stat,HDB 99.6%,HDB 99%,X WS 1%,X WS 2.5%,X WS
5%,CM WS .4%,CM MDB .4%,CM WS 1%,CM MDB 1%,MWS 99.6%,PWD 99.6%,MWS .4%,PWD .4%,X MnDB Max,X MnDB Min,X
StdDB Max,X StdDB Min,Design Stat,CDB .4%,C MWB .4%,CDB 1%,C MWB 1%,CDB 2%,C MWB 2%,E WB .4%,E MDB .4%,E
WB 1%,E MDB 1%,E WB 2%,E MDB 2%,DP .4%,HR .4%,MDB .4%,DP 1%,HR 1%,MDB 1%,DP 2%,HR 2%,MDB 2%,DB Range
,,Units,{°C},{°C},{m/s},{m/s},{m/s},{°C},{m/s},{°C},{m/s},{Degree},{m/s},{Degree},{°C},{°C},{°C},{°C
},Units,{°C},{°C},{°C},{°C},{°C},{°C},{°C},{°C},{°C},{°C},{°C},{°C},{g/kg},{°C},{°C},{g/kg},{°C},{°C}
,{g/kg},{°C},{°C}
1,World Climate Design Data 2001 ASHRAE
Handbook,HEATING,5.8,6.8,11.3,9.9,8.8,11.1,14.2,9.1,13.4,1.1,320,5.3,300,39.3,3.1,2.9,1.9,COOLING,32.2,20,
29.5,19.7,27.9,20.1,23,28,22.3,26.2,21.7,25.3,21.7,16.4,24.8,21.1,15.8,24.3,20.6,15.3,23.9,6.7
```

However, if there are no design conditions, then the format looks like:

```
Number of Design Conditions,Title of Design Condition,
0
```

Theoretically, there can be more than one design condition included.

Typical/Extreme Periods Header/Data (CSV)

The results from the typical / extreme period heuristic calculation are shown.

```
Number of Typical/Extreme Periods,Period Name,Period Type,Period Start Day,Period End Day,<repeat to #
periods>
6,Summer - Week Nearest Max Temperature For Period,Extreme,1/ 4,1/10,Summer - Week Nearest Average
Temperature For Period,Typical,11/29,12/ 5,Winter - Week Nearest Min Temperature For Period,Extreme,7/
3,7/ 9,Winter - Week Nearest Average Temperature For Period,Typical,6/ 5,6/11,Autumn - Week Nearest
Average Temperature For Period,Typical,3/22,3/28,Spring - Week Nearest Average Temperature For
Period,Typical,8/ 1,8/ 7
```

Ground Temperatures Header/Data (CSV)

The results from the ground temperature heuristic calculation are shown, typically for 3 depths. Users may also fill in the blank fields (soil conductivity, soil density, soil specific heat) with known values and/or perform their own calculations and depths and supply those.

```
Number of Ground Temperature Depths,Ground Temperature Depth {m},Soil Conductivity {W/m-K},Soil Density
{kg/m3},Soil Specific Heat {J/kg-K},Jan {C},Feb{C},Mar {C},Apr {C},May {C},Jun {C},Jul {C},Aug {C},Sep
{C},Oct {C},Nov {C},Dec {C},<repeat to Number of temperature depths>
3,.5,,,,20.69,22.30,22.69,22.26,19.95,17.43,15.09,13.43,12.99,13.86,15.84,18.29,2,,,,19.18,20.71,21.41,21.
40,20.16,18.43,16.58,15.03,14.25,14.45,15.59,17.28,4,,,,18.18,19.38,20.10,20.30,19.82,18.80,17.56,16.35,15
.56,15.39,15.89,16.89
```

Holiday/Daylight Saving Header/Data (CSV)

If these data are entered, the weather converter will process them. Default weather processing contains no holidays or daylight saving period. Of course, these can also be specified in your input data file for EnergyPlus and do not need to be embedded in the weather file.

```
Leap Year Observed?,Daylight Saving Start Date,Daylight Saving End Date,Number of Holidays,Holiday
Name,Holiday Date,<repeat for # Holidays>
No,0,0,0
```

Comment 1 Header/Data (CSV)

Some original data files fill the comment 1 header and some do not. Typically, it will display at least a "station" number and potentially more information.

```
Comment Line #1
"IWEC- WMO#947670 - South-west Pacific -- Original Source Data (c) 2001 American Society of Heating,
Refrigerating and Air-Conditioning Engineers (ASHRAE), Inc., Atlanta, GA, USA.  www.ashrae.org  All rights
reserved as noted in the License Agreement and Additional Conditions. DISCLAIMER OF WARRANTIES: The data
is provided 'as is' without warranty of any kind, either expressed or implied. The entire risk as to the
quality and performance of the data is with you. In no event will ASHRAE or its contractors be liable to
you for any damages, including without limitation any lost profits, lost savings, or other incidental or
consequential damages arising out of the use or inability to use this data."
```

Comment 2 Header/Data (CSV)

```
Comment Line #2
 -- Ground temps produced with a standard soil diffusivity of 2.3225760E-03 {m**2/day}
```

Data Period Header/Data (CSV)

```
Number of Data Periods [DP],Number of Intervals per Hour,DP Name/Description,DP Start Day of Week,DP Start
Day, DP End Day,<repeat to # Data Periods>
1,1,Data,Sunday, 1/ 1,12/31
```

Data Records (CSV)

The field "names" for each item are shown. First, the "short" names:

```
Date,HH:MM,Datasource,DryBulb {C},DewPoint {C},RelHum {%},Atmos Pressure {Pa},ExtHorRad {Wh/m2},ExtDirRad
{Wh/m2},HorIRSky {Wh/m2},GloHorRad {Wh/m2},DirNorRad {Wh/m2},DifHorRad {Wh/m2},GloHorIllum
{lux},DirNorIllum {lux},DifHorIllum {lux},ZenLum {Cd/m2},WindDir {deg},WindSpd {m/s},TotSkyCvr
{.1},OpaqSkyCvr {.1},Visibility {km},Ceiling Hgt {m},PresWeathObs,PresWeathCodes,Precip Wtr {mm},Aerosol
Opt Depth {.001},SnowDepth {cm},Days Last Snow
```

Then, the longer names:

```
Date,HH:MM,Datasource,Dry Bulb Temperature {C},Dew Point Temperature {C},Relative Humidity {%},Atmospheric
Pressure {Pa},Extraterrestrial Horizontal Radiation {Wh/m2},Extraterrestrial Direct Normal Radiation
{Wh/m2},Horizontal Infrared Radiation Intensity from Sky {Wh/m2},Global Horizontal Radiation
{Wh/m2},Direct Normal Radiation {Wh/m2},Diffuse Horizontal Radiation {Wh/m2},Global Horizontal Illuminance
{lux},Direct Normal Illuminance {lux},Diffuse Horizontal Illuminance {lux},Zenith Luminance {Cd/m2},Wind
Direction {deg},Wind Speed {m/s},Total Sky Cover {.1},Opaque Sky Cover {.1},Visibility {km},Ceiling Height
{m},Present Weather Observation,Present Weather Codes,Precipitable Water {mm},Aerosol Optical Depth
{.001},Snow Depth {cm},Days Since Last Snow
```

As noted previously, these headers and data are in the identical order to the items in the EPW records. Then the data is shown:

```
1983/1/1,01:00,C9C9C9C9*0?9?9?9?9?9?9?9*0C8C8C8C8*0*0E8*0*0,26.2,19.2,65,101100,0,1415,412,0,0,0,0,0,0,0,1
80,6.5,9,7,23.3,77777,9,'999999999,0,0.2300,0,88
```

The Date and Time fields need a bit of description. The Date field (e.g. 1983/1/1) uses your standard system date for formatting. In the EPW file, these are three separate fields (year, month, and day in this example). The time field combines the hours and minutes into one field (hh:mm). This makes it easier for graphing with spreadsheet programs but a bit harder if you use the CSV format as input.

Each data item field obeys the same "missing" rules as shown above in the EPW data layout.

Missing Weather File Data

The following data contains "missing" descriptors, a new concept not introduced previously in our IDD conventions. In this case, it will be processed as though those values are "missing" in the weather conversions. This may not always be desirable though the weather processor will fill in "missing" value with something "appropriate". Eventually, these missing values will be available through the weather processor. Until then, the following are used for initial missing conditions. When a valid value is encountered from weather data, however, it will become the new "missing" replacement value:

Table 6. Missing weather replacement values

Data item	Supplied Value	Units
Dry Bulb Temperature	6	C
Dew Point Temperature	3	C
Relative Humidity	50	%
Atmospheric Pressure	Standard** Barometric Pressure (altitude based)	Pa
Wind Speed	2.5	m/s
Wind Direction	180	Deg
Total Sky Cover	5	(tenths)
Opaque Sky Cover	5	(tenths)
Visibility	777.7	Km
Ceiling Height	77777	m

Precipitable Water	0	Mm
Aerosol Optical Depth	0	Broadband turbidity
Snow Depth	0	Cm
Days Since Last Snow	88	Days
Radiation Values (Direct/Diffuse)	0.0	Wh/m2
Illuminance Values	0.0	lux (or CD/m2)

**Standard Barometric pressure based on location elevation is taken from ASHRAE 2001 Handbook of Fundamentals, pages 6.1 & 6.2.

Source Weather Data Formats

Source weather data for building energy simulation programs can be broken into two major classes: *historical data* and *typical weather years*. Historical data is just "real" data: usually measured (but sometimes modeled) data from a particular location for a given period of record. Typical years are ersatz years assembled to match the long term data from a particular location using a particular statistical measure. Typical data may also be "real" data but may not be a contiguous year – the data may be comprised of months from multiple years.

The primary source for historical weather data is the U.S. National Climatic Data Center (NCDC) in Asheville, NC: http://www.ncdc.noaa.gov/. NCDC can provide hourly historical data for thousands of locations around the world. This data may not always be complete; data items or periods of record may be missing.

Data Set vs. Data Format

In this document as well in many others, you will read about a certain "data set" and you will also read about data in a "certain" format – e.g., the TMY2 data set and the TMY2 data format. Simply stated, a data set refers to a set of data files developed around a set of procedures for selection and usually with a specific purpose for use. A data format is merely the identification of data elements in a data file. In the TMY2 example, the TMY2 data set was developed as described below and the format of the data is usually called a TMY2 format.

Any data *could* be put into a TMY2 format, but it wouldn't necessarily be selected using the same procedures as the TMY2 data set.

SAMSON Data Set/Format

A highly reliable source of historical data for U.S. locations is the Solar and Meteorological Surface Observational Network (SAMSON) data set assembled by the National Renewable Energy Laboratory (NREL) in Golden, CO: http://www.nrel.gov/. The SAMSON data set contains a 30 year (1961 to 1990) period of record for 239 locations and are available from the NCDC.

SAMSON also describes a file format. Though no data from the SAMSON data set are available for download in EPW format, the weather conversion utility can read and process this file format.

TMY2 Data Set/Format

The TMY2 are data sets of hourly values of solar radiation and meteorological elements for a 1-year period. Their intended use is for computer simulations of solar energy conversion systems and building systems to facilitate performance comparisons of different system

types, configurations, and locations in the United States and its territories. Because they represent typical rather than extreme conditions, they are not suited for designing systems to meet the worst-case conditions occurring at a location. The data are available from the National Renewable Energy Laboratory for download or on CD.

All of the TMY2 data are available for download (in EPW format) from the EnergyPlus web site.

WYEC2 Data Set/Format

Culminating in the early 1980s, ASHRAE published their "Weather Year for Energy Calculations" (WYEC) hourly weather files for 51 US and Canadian locations. These files were intended to support the then growing interest in computer simulation of energy use in buildings. In the late 1980s, a major revision was initiated – this included the addition of 26 Typical Meteorological Year (TMY) hourly weather files to the original WYEC data set and a number of improvements.

The work of revising and improving the WYEC data base was performed by at the National Renewable Energy Laboratory (NREL) as part of the Solar Radiation Resource Assessment Program (SRRAP), during the period 1989 through 1993. Richard Perez, at the State University of New York at Albany -- Atmospheric Sciences Research Center provided a substantial contribution to this work. The resulting set of 77 revised and corrected hourly weather files are referred to as WYEC Version 2 or "WYEC2" data set.

The WYEC2 format is used as the format for several other data sets. The WYEC2 data set, however, was not made available for download though, of course, those files can be read if desired with the EnergyPlus Weather Converter utility.

Canadian Weather for Energy Calculations (CWEC)

Produced by Numerical Logics in collaboration with Environment Canada and the National Research Council of Canada, the CWEC were derived using a methodology similar to the TMY2 and TMY. CWEC hourly files represent weather conditions that result in approximately average heating and cooling loads in buildings. The National Energy Code of Canada requires the use of a CWEC file representative of a location when the performance path and customized design calculations are chosen as the means of building energy consumption compliance. The CWEC follow the ASHRAE WYEC2 format and were derived from the Canadian Energy and Engineering Data Sets (CWEEDS) of hourly weather information for Canada from the 1953-1995 period of record.

The 55 CWEC files contain hourly weather observations representing an artificial one-year period specifically designed for building energy calculations. All 55 locations in the CWEC data set are available for download in EnergyPlus weather format.

International Weather for Energy Calculations (IWEC)

The IWEC are the result of ASHRAE Research Project 1015 conducted by Numerical Logics and Bodycote Materials Testing Canada for ASHRAE Technical Committee 4.2 Weather Information. The IWEC data files are 'typical' weather files suitable for use with building energy simulation programs for 227 locations outside the USA and Canada.

The files are derived from up to 18 years of DATSAV3 hourly weather data originally archived at the U S National Climatic Data Center. The weather data is supplemented by solar radiation estimated on an hourly basis from earth-sun geometry and hourly weather elements, particularly cloud amount information. The IWEC CD-ROM is available from ASHRAE.

The Department of Energy has licensed the IWEC data from ASHRAE. Our license with ASHRAE allows us to: "Distribute versions of the individual IWEC files in converted format

suitable for EnergyPlus (EPW). Make the EnergyPlus versions of the IWEC files available to users at no cost via this EnergyPlus web site." All 227 locations in the IWEC data set are available for download in EnergyPlus weather format.

The IWEC source data is © 2001 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Inc., Atlanta, GA, USA. http://www.ashrae.org/ All rights reserved as noted in the License Agreement and Additional Conditions.

IWEC also describes a data format, very similar to the TMY2 data format.

Typical Meteorological Year (TMY)

Data for 230 locations in the USA plus four locations in Cuba, Marshall Islands, Palau, and Puerto Rico, derived from a 1948-1980 period of record. Many of the locations in the TMY data set were subsequently updated by the TMY2.

Similar to the TMY2, the TMY are data sets of hourly values of solar radiation and meteorological elements for a 1-year period. Their intended use is for computer simulations of solar energy conversion systems and building systems to facilitate performance comparisons of different system types, configurations, and locations in the United States and its territories. Because they represent typical rather than extreme conditions, they are not suited for designing systems to meet the worst-case conditions occurring at a location. The data are available for purchase from the National Climatic Data Center.

The 42 TMY locations that do not duplicate TMY2 locations are available for download in EnergyPlus weather format.

TMY also describes a data format.

California Climate Zones 2 (CTZ2)

Updated weather data for 16 California climate zones for use to demonstrate compliance with Title 24 with approved building energy simulation programs. All 16 CTZ2 weather files are available for download in EnergyPlus weather format. The original source data is available from the California Energy Commission. These source data files are described using the WYEC2 format.

Other Formats

The data sets and formats described above are some of the newest formats available for use with building simulation programs.

Source data comes in various formats. Typically the files are ASCII, but the data items, units, item location, and record length vary from format to format. NCDC can provide historical data in a variety of formats: TD-3280, TD-3510, TD-9950 (DATSAV2), TD-9956 (DATSAV3) and TD-1440 (CD144). Of these, the EnergyPlus weather processor cannot process any of the types (yet).

One other format worth mentioning is TRY. This is the format of an old, "test reference year" data set that did not include solar radiation data. "Test Reference Year" is a term that usually denotes selection of a specific year of "real" data based on some statistical procedure. The original TRY data (TD-9706) was based on an ASHRAE procedure to select the data from a "period of record". "The principle of the selection is to eliminate years in the period of record containing months with extremely high or low mean temperatures until only one year remains." The weather conversion utility cannot process data in "TRY" format. However, many organizations develop data for reference year data (e.g. European TRY, Moisture Reference Data).

Solar Data

Source weather data files may or may not contain solar data. All of the files that can be processed by the EnergyPlus Weather conversion utility contain solar data. The weather processor will transfer this data to the EPW weather file and it will be used by the EnergyPlus simulation program.

Historical weather data files in CD144 format do not contain solar data nor is such data generally available for a specific location and time period. In this case, ersatz solar data must be generated from cloud cover and other data using sky models and regression formulas. Currently, neither the Weather Conversion utility nor the EnergyPlus program synthesizes this data.

Table 7. Summary of Downloadable Weather Data by Type

	USA	Canada	International	Total
TMY2	237		2	239
TMY	38		4	42 (not duplicating TMY2)
CTZ	4			4 (not duplicating TMY/TMY2)
CTZ2	16		16	
CWEC		55		55
IWEC			227	227
Totals	279 (+16 CTZ2)	55	233	583

Data Sources/Uncertainty

More recent weather data source files have introduced the concept of data sources and uncertainty flags for many of the fields. The EnergyPlus weather format faithfully reproduces these fields as appropriate for the input source data types. By and large, most of the data sources and uncertainties have used the TMY2 established fields and values (See following table). As noted earlier, to enhance readability and reduce obfuscation, the EnergyPlus format for the data source and uncertainty flags collates them into one large field. Each data element still has it's data source and uncertainty: it is positionally embodied depending on its place in the EPW data record.

Table 8. Key to Data Source and Uncertainty Flags

Data Flag	Flag Values
Dry Bulb Temperature Data Source	A-F
Dry Bulb Temperature Data Uncertainty	0-9
Dew Point Temperature Data Source	A-F
Dew Point Temperature Data Uncertainty	0-9
Relative Humidity Data Source	A-F
Relative Humidity Data Uncertainty	0-9
Atmospheric Station Pressure Data Source	A-F
Atmospheric Station Pressure Data Uncertainty	0-9

Horizontal Infrared Radiation Data Source	A-H, ?
Horizontal Infrared Radiation Data Uncertainty	0-9
Global Horizontal Radiation Data Source	A-H, ?
Global Horizontal Radiation Data Uncertainty	0-9
Direct Normal Radiation Data Source	A-H, ?
Direct Normal Radiation Data Uncertainty	0-9
Diffuse Horizontal Radiation Data Source	A-H, ?
Diffuse Horizontal Radiation Data Uncertainty	0-9
Global Horizontal Illuminance Data Source	I, ?
Global Horizontal Illuminance Data Uncertainty	0-9
Direct Normal Illuminance Data Source	I, ?
Direct Normal Illuminance Data Uncertainty	0-9
Diffuse Horizontal Illuminance Data Source	I, ?
Diffuse Horizontal Illuminance Data Uncertainty	0-9
Zenith Luminance Data Source	I, ?
Zenith Luminance Data Uncertainty	0-9
Wind Direction Data Source	A-F
Wind Direction Data Uncertainty	0-9
Wind Speed Data Source	A-F
Wind Speed Data Uncertainty	0-9
Total Sky Cover Data Source	A-F
Total Sky Cover Data Uncertainty	0-9
Opaque Sky Cover Data Source	A-F
Opaque Sky Cover Data Uncertainty	0-9
Visibility Data Source	A-F, ?
Visibility Data Uncertainty	0-9
Ceiling Height Data Source	A-F, ?
Ceiling Height Data Uncertainty	0-9
Precipitable Water Data Source	A-F
Precipitable Water Data Uncertainty	0-9
Broadband Aerosol Optical Depth Data Source	A-F
Broadband Aerosol Optical Depth Data Uncertainty	0-9
Snow Depth Data Source	A-F, ?
Snow Cover Data Uncertainty	0-9
Days Since Last Snowfall Data Source	A-F, ?
Days Since Last Snowfall Data Uncertainty	0-9

The definition of the solar radiation source flags and solar radiation uncertainty flags are shown in the following two tables:

Table 9. Solar Radiation and Illuminance Data Source Flag Codes

Flag Code	Definition
A	Post-1976 measured solar radiation data as received from NCDC or other sources
B	Same as "A" except the global horizontal data underwent a calibration correction
C	Pre-1976 measured global horizontal data (direct and diffuse were not measured before 1976), adjusted from solar to local time, usually with a calibration correction
D	Data derived from the other two elements of solar radiation using the relationship, global = diffuse + direct ´ cosine (zenith)
E	Modeled solar radiation data using inputs of observed sky cover (cloud amount) and aerosol optical depths derived from direct normal data collected at the same location
F	Modeled solar radiation data using interpolated sky cover and aerosol optical depths derived from direct normal data collected at the same location
G	Modeled solar radiation data using observed sky cover and aerosol optical depths estimated from geographical relationships
H	Modeled solar radiation data using interpolated sky cover and estimated aerosol optical depths
I	Modeled illuminance or luminance data derived from measured or modeled solar radiation data
?	Source does not fit any of the above categories. Used for nighttime values and missing data

Table 10. Solar Radiation and Illuminance Data Uncertainty Flag Codes

Flag	Uncertainty Range (%)
1	Not used
2	2 - 4
3	4 - 6
4	6 - 9
5	9 - 13
6	13 - 18
7	18 - 25
8	25 - 35
9	35 - 50
0	Not applicable

Finally, the Meteorological data source and uncertainty flag/codes are shown in the following two tables:

Table 11. Meteorological Data Source Flag Codes

Flag	Definition
A	Data as received from NCDC, converted to SI units
B	Linearly interpolated
C	Non-linearly interpolated to fill data gaps from 6 to 47 hours in length
D	Not used
E	Modeled or estimated, except: precipitable water,

	calculated from radiosonde data; dew point temperature calculated from dry bulb temperature and relative humidity; and relative humidity calculated from dry bulb temperature and dew point temperature
F	Precipitable water, calculated from surface vapor pressure; aerosol optical depth, estimated from geographic correlation
?	Source does not fit any of the above. Used mostly for missing data

Table 12. Meteorological Uncertainty Flag Codes

Flag	Definition
1- 6	Not used
7	Uncertainty consistent with NWS practices and the instrument or observation used to obtain the data
8	Greater uncertainty than 7 because values were interpolated or estimated
9	Greater uncertainty than 8 or unknown.
0	Not definable.

Interface to the EPlusWth.dll

To provide information for outside developers/interfaces that might want to use the basic weather processing utility from within their interface, the EPlusWth.dll was developed. It is actually used by the weather converter utility. In addition to the basic interface calls, six important files are also used by this library. These are placed in the WeatherConverter folder during install of EnergyPlus.

Files used by EPlusWth.dll

Each of the files is in a general comma-delimited format. Thus, they can be easily viewed by importing into a spreadsheet program such as Excel™. The files are used to support information lacking in the source data files and/or supply additional information used during the conversion process. In each case (with one exception), there will be a single or set of "header" records describing each column of the file and then the data values of the file will follow on subsequent records. Each of the files is described briefly in the next few sections.

Abbreviations.csv

This file does not have a header record, but it consists of 3 columns. It is used for data files that might have 2-character abbreviations for US States or Canadian provinces and provides a translation to the full name and 3-character country code. Likewise, it can use the full name of these items to obtain the 2-character abbreviation or 3-character country code.

WBANLocations.csv

In many older data sets, the station identifier for the weather data uses the WBAN (Weather Bureau Army-Navy) designation system. This has largely been superceded by the WMO (World Meteorological Organization) designation for station collection site identifiers. This file

provides a translation between the two identifier systems. In addition, this file contains latitude, longitude, time zone and elevation information for the sites.

Cal Climate Zone Lat Long data.csv

Note that this file has spaces in the name. The California climate zone data source files do not have standard station identifiers. Rather they use a climate zone designator from 1-16. This file is used to obtain the latitude, longitude, time zone and elevation data for these climate zones. The WYEC2 "File Source Code" (field 2, column 6 of each data record) is used to determine that the file is a California compliance type file.

USDesignConditions.csv

CanadaDesignConditions.csv

WorldDesignConditions.csv

The three files for design conditions have roughly the same format. These are the values from the ASHRAE Handbook of Fundamentals, 2001, Chapter 27, SI Tables 1a, 1b, 2a, 2b, 3a, 3b, 4a, 4b. The WMO station identifier is used to determine the design condition values that apply to a source data file and, thus, are included in the DESIGN CONDITION header record on the EPW file produced as part of the conversion. This information is also included in the statistical report file (STAT) produced from the weather converter utility. In addition, these are used to supply the information for the design day object (DDY) file creation.

Public calls to EPlusWth.dll

Several points of the library are made available for use with external programs. In each case the parameters passed will be described along with the Visual Basic™ (VB6) code that is used to declare them as well as Fortran 90 style "Interface" statements to the same calls. The library is placed in the same folder with the weather converter utility – you may need to copy it to your program's folder if you choose to add external calls from your program to it.

SetupPWInternalDataPath

This call designates the "path" to the files listed above. This is the location where the ProcessWeather call will expect to find the files. Having this incorrectly specified is not fatal, but will probably cause confusion.

VB declaration statement:

```
Private Declare Sub SetupPWInternalDataPath Lib "EPlusWth" (ByVal strPath As
String, ByVal InPathLen As Long)
```

And a call from a VB program:

```
Call SetupPWInternalDataPath(AppPath, Len(AppPath))
```

Likewise for Fortran 90/95:

```
  INTERFACE
    SUBROUTINE SetupPWInternalDataPath (Path)
    CHARACTER(len=*), INTENT(IN) :: Path    ! Path where data files reside
    END SUBROUTINE
  END INTERFACE
```

And then calling it from Fortran:

```
Character(len=255) DataPath
CALL SetupPWInternalDataPath(trim(DataPath))
```

SetFixOutOfRangeData

As shown earlier (file menu option in the weather converter utility), there is an option to "fix" out of range data or not. By default, this is turned off (does not fix data). Again a character convention ("yes" for fixing; "no" for not fixing) is used. Case of the actual string is ignored.

VB Declaration statement:

```
Private Declare Sub SetFixOutOfRangeData Lib "EPlusWth" (ByVal strValue As
String, ByVal strValueLen As Long)
```

And calling it from VB:

```
    Global FixOutOfRangeData As String
    FixOutOfRangeData = "Yes"
    Call SetFixOutOfRangeData(FixOutOfRangeData, Len(FixOutOfRangeData))
```

For Fortran 90/95:

```
  INTERFACE
    SUBROUTINE SetFixOutOfRangeData (YesNo)
    CHARACTER(len=*),INTENT(IN) :: YesNo    ! 'yes' to set fixing option;
                                            ! 'no' to not
    END SUBROUTINE
  END INTERFACE
```

And then calling it:

```
CALL SetFixOutOfRangeData('no')
```

SetDefaultChgLimit

This call sets the value for the DB trigger shown earlier. Both values passed in are strings and are specific to the dialog shown earlier:

Table 13. Trigger Limit Call Values

Trigger Limit	Result	Ignore Calc Trigger	Result
0	use only calculated trigger	0	Uses Calculated Trigger
1	use 5°C	1	Ignores calculated trigger
2	use 10°C		
3	use 15°C		

You can also choose to ignore the calculated trigger entirely. If you do not "ignore" the calculated trigger, then the trigger is the minimum of the calculated and your trigger limit selection.

VB Declaration Statement:

```
Private Declare Sub SetDefaultChgLimit Lib "EPlusWth" (ByVal strValue As
String, ByVal strValueLen As Long, ByVal strValue As String, ByVal
strValueLen As Long)
```

And a call from VB:

```
    Call SetDefaultChgLimit(TriggerLimit, Len(TriggerLimit),
IgnoreCalcTrigger, Len(IgnoreCalcTrigger))
```

ProcessWeather

The "meat" of the processing is done by this routine. It gets passed the input file name (source data), the input file type, output file name, output file type. As an output it can provide a notice that the processing was successful or not.

VB Declaration Statement:

```
Private Declare Sub ProcessWeather Lib "EPlusWth" (ByVal strInType As String,
ByVal InTypeLen As Long, ByVal strOutType As String, ByVal OutTypeLen As
Long, ByVal strInFileName As String, ByVal InFileNameLen As Long, ByVal
strOutFileName As String, ByVal OutFileNameLen As Long, ErrorFlag As Boolean)
```

Calling it from VB:

```
Call ProcessWeather(InputFileDataType, Len(InputFileDataType),
     OutputFileDataType, Len(OutputFileDataType),
     InputFileName, Len(InputFileName),
     OutputFileName, Len(OutputFileName),
     ErrorFlag)
```

Valid values for the Input File Data Type are shown in the following table:

Table 14. Valid Input File Types for "ProcessWeather" call

Input File Type	Source Data file Format Type
TMY2 or TM2	TMY2 data file
IWEC or IWC	IWEC data file
SAMSON or DAT	SAMSON data file
WYEC2 or WY2	WYEC2 data file
FMT or TXT	DOE-2 Formatted data file
CLM or ESP-r	ESP-r formatted data file
BLAST or ASC	BLAST ASCII formatted data file
EPW	EnergyPlus EPW file
CSV	EnergyPlus CSV file
TMY	TMY data files

Valid values for the Output File Type(s) are shown in the following table:

Table 15. Valid Output File Types for the "ProcessWeather" call

Output File Type	File(s) produced
EPW	EPW and RPT files
CSV	CSV and RPT files
BOTH	EPW, CSV and RPT files
RPT	RPT file

For Input and Output file names, the complete paths should be included.

ErrorFlag will be returned as "true" if an error occurs during processing or "false" if the process is successful.

Fortran 90/95 Declaration:

```
INTERFACE
```

```
  SUBROUTINE ProcessWeather(InType,OutType,InFileName,OutFileName,ErrFlag)
    CHARACTER(len=*), INTENT(IN) :: InType      ! InputFile Type
    CHARACTER(len=*), INTENT(IN) :: OutType     ! OutputFile Type
    CHARACTER(len=*), INTENT(IN) :: InFileName  ! InputFile Name (Full path)
    CHARACTER(len=*), INTENT(IN) :: OutFileName ! OutputFileName (Full path)
    LOGICAL(Byte2), INTENT(OUT)  :: ErrFlag     ! If errors are found,
                                                ! set to true and put
                                                ! description put in file.

  END SUBROUTINE
END INTERFACE
```

And calling it from Fortran:

```
call processweather(trim(intype),trim(outtype),    &
                 trim(infilename),trim(outfilename),errflag)
```

Note that the file where error messages will be placed is the RPT file. If the value of the output file path is incorrect, you may need to search for this file by using the RPT extension.

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Web Resources

Building Energy Tools Directory, a directory of information on 250+ energy tools from around the world.

http://www.energytoolsdirectory.gov/

Energy Systems Research Unit, University of Strathclyde, authors of ESP-r, up-to-date information on ESP-r and other energy systems research and software development.

http://www.strath.ac.uk/Departments/ESRU

EnergyPlus, up-to-date information on the current status of EnergyPlus and working with the team, and documentation such as input data structure, output data structure, and licensing opportunities. Additional weather files may be posted here as well.

http://www.energyplus.gov

Ground Heat Transfer in EnergyPlus

Introduction

There are two difficulties behind linking ground heat transfer calculations to EnergyPlus. One is the fact that the conduction calculations in EnergyPlus (and in DOE–2 and BLAST before it) are one-dimensional and the ground heat transfer calculations are two or three-dimensional. This causes severe modeling problems irrespective of the methods being used for the ground heat transfer calculation. The other difficulty is the markedly different time scales involved in the processes. Basically, the zone model is on an hour scale and the ground heat transfer is on a monthly time scale. The basic heat balance based zone model of EnergyPlus has to be considered as the foundation for building energy simulation at the present time and for some time in the future. Thus, it is necessary to be able to relate ground heat transfer calculations to that model.

The heat balance zone model considers a single room or thermal zone in a building and performs a heat balance on it. A fundamental modeling assumption is that the faces of the enclosure are isothermal planes. A ground heat transfer calculation usually considers an entire building and the earth that surrounds it, resulting in non-isothermal face planes where there is ground contact. While it is not impossible to imagine muli-zone, whole building models that include the surrounding earth and non-isothermal building surfaces, such models will not be practical for some time in the future, and their usefulness even then is not clear.

The EnergyPlus development team addressed the problem and decided that the most reasonable first step would be to partially decouple the ground heat transfer calculation from the thermal zone calculation. The most important parameter for the zone calculation is the outside face temperature of the building surface that is in contact with the ground. Thus this becomes a reasonable "separation plane" for the two calculations. It was further decided that the current usage of monthly average ground temperature was reasonable for this separation plane temperature as well, since the time scales of the building heat transfer processes are so much shorter than those of the ground heat transfer processes.

Using the separation plane premise, the 3D ground heat transfer programs for slabs developed by Bahnfleth (1989,1990) were modified by Clements (2003) to produce outside face temperatures. The program has recently been modified to permit separate monthly average inside temperatures as input. The program produces outside face temperatures for the core area and the perimeter area of the slab.

In a 2004 release, a 3D basement program may also be included with EnergyPlus. The results from it will be used in a similar way. For the near term it is suggested that the perimeter outside face temperatures be used on the outside of basement walls in contact with the ground, and the core values be used for the basement floor.

It should be noted that either for slabs or basements the ground heat transfer is usually small unless the building is very small or has some special characteristics.

Use of the Ground Temperatures

The slab program produces temperature profiles for the outside surface at the core and at the perimeter of the slab. It also produces the average based on the perimeter and core areas used in the calculation. EnergyPlus has a single *GroundTemperatures* object that is used for twelve monthly average ground temperature values – see the Input Output Reference document. Because of this, there are two options for dealing with the ground temperatures.

Option 1:   Use the average temperatures produced by the slab program for the *GroundTemperatures* object. This will provide an average ground temperature at the outside face of any heat transfer surface whose *OutsideFaceEnvironment* field is "ground".

Option 2: If two or more ground temperature conditions are desired, it is necessary to utilize the ground temperature modification feature of other side coefficients (OtherSideCoef field in OutsideFaceEnvironment).   Then, for example, if core and perimeter temperatures are wanted, the perimeter temperatures from the slab program should be specified in the *GroundTemperatures* object, and the surface associated with that condition is treated as in option 1 above. The surface that is to be exposed to the core temperature should be given the OtherSideCoef designation, and the *OtherSideCoefficients* object should be used to specify the temperatures. To do this, all of the numerical fields in this object should be zero except field N5. This field should contain the ratio of the average annual core temperatures and average annual perimeter temperatures. In other words, the resulting core profile values will be N5 times the perimeter values. This same procedure can be used to generate as many profiles as needed. However, it should be noted that they will all have the same profile as the *GroundTemperatures* object values.

The program has been modified so that the inside temperature can be more complex than a year long average. It is now possible to input twelve separate monthly average inside temperatures. In addition, it is possible to add a hourly sinusoidal variation of the inside temperature with a 24 hour period sine function. This was included to show the effect of something such as night setback on the face temperature. Generally the effect is quite small.

First the results for a monthly specified constant average inside temperature. The location is Minneapolis, and the slab is insulated.

```
              Monthly Slab Outside Face Temperatures, C
             Perimeter Area: 304.00   Core Area: 1296.00
         Month    Average    Perimeter     Core      Inside
           1       17.67      16.11       18.03       18.0
           2       17.45      15.92       17.81       18.0
           3       17.43      16.07       17.74       18.0
           4       19.00      17.82       19.27       20.0
           5       19.24      18.23       19.48       20.0
           6       19.31      18.42       19.52       20.0
           7       20.92      20.14       21.11       22.0
           8       21.17      20.44       21.35       22.0
           9       21.22      20.45       21.40       22.0
          10       21.21      20.26       21.44       22.0
          11       19.62      18.54       19.88       20.0
          12       19.35      17.99       19.67       20.0
```

The resulting heat flux is shown below. The inside heat transfer coefficient and slab thermal properties are specified in the input file. For this example the total thermal resistance from the inside air to the slab bottom surface was 0.27 (m^2 C)/W . This value is controlled by the user with the inside heat transfer coefficient and slab thermal properties values in the slab program input file.

Month	Average	Perimeter	Core	Inside	Perimeter Heat Flux W/m^2	Average Heat Flux W/m^2
1	17.67	16.11	18.03	18	7.00	1.22
2	17.45	15.92	17.81	18	7.70	2.04
3	17.43	16.07	17.74	18	7.15	2.11
4	19	17.82	19.27	20	8.07	3.70
5	19.24	18.23	19.48	20	6.56	2.81
6	19.31	18.42	19.52	20	5.85	2.56
7	20.92	20.14	21.11	22	6.89	4.00

8	21.17	20.44	21.35	22	5.78	3.07
9	21.22	20.45	21.4	22	5.74	2.89
10	21.21	20.26	21.44	22	6.44	2.93
11	19.62	18.54	19.88	20	5.41	1.41
12	19.35	17.99	19.67	20	7.44	2.41

Then for the same conditions, the results with a 2 degree C amplitude 24 hour sin wave variation. Notice that the inside temperatures are the same since they are monthly averages and the daily variation oscillates about the mean. The core and perimeter slab temperatures are affected slightly.

```
                 Monthly Slab Outside Face Temperatures, C
                Perimeter Area: 304.00  Core Area: 1296.00
             Month   Average   Perimeter    Core      Inside
              1       17.51     16.03      17.86       18.0
              2       17.29     15.85      17.63       18.0
              3       17.27     16.00      17.57       18.0
              4       18.87     17.77      19.13       20.0
              5       19.11     18.16      19.34       20.0
              6       19.17     18.34      19.37       20.0
              7       20.81     20.07      20.98       22.0
              8       21.05     20.36      21.21       22.0
              9       21.09     20.38      21.26       22.0
             10       21.08     20.19      21.29       22.0
             11       19.47     18.45      19.71       20.0
             12       19.20     17.92      19.51       20.0
```

An example of a 24 hour inside temperature profile for this case is shown below. The sine wave amplitude was 2 C.

```
      Day      Hour    Perim Out Ts    Core Out Ts    Inside Temp
       1        1       17.30827       19.15832       18.51749
       1        2       17.29503       19.15274       18.99974
       1        3       17.30236       19.16732       19.41389
       1        4       17.32258       19.19376       19.73175
       1        5       17.34834       19.22526       19.93166
       1        6       17.37288       19.25529       20.00000
       1        7       17.39023       19.27798       19.93212
       1        8       17.39544       19.28838       19.73265
       1        9       17.38485       19.28117       19.41517
       1       10       17.35602       19.24733       19.00130
       1       11       17.30590       19.18686       18.51924
       1       12       17.23507       19.10210       18.00180
       1       13       17.14650       18.99703       17.48425
       1       14       17.04291       18.87713       17.00183
       1       15       16.92873       18.74895       16.58738
       1       16       16.81076       18.61963       16.26915
       1       17       16.69609       18.49656       16.06881
       1       18       16.59243       18.38671       16.00000
       1       19       16.50669       18.29626       16.06741
       1       20       16.44276       18.23010       16.26645
       1       21       16.40369       18.19161       16.58356
       1       22       16.38873       18.18218       16.99714
       1       23       16.39435       18.19834       17.47902
       1       24       16.41942       18.23298       17.99639
```

A plot of the daily profiles is shown below. Note that the inside temperature change of 4 C produces only a small change in the slab lower face temperature.
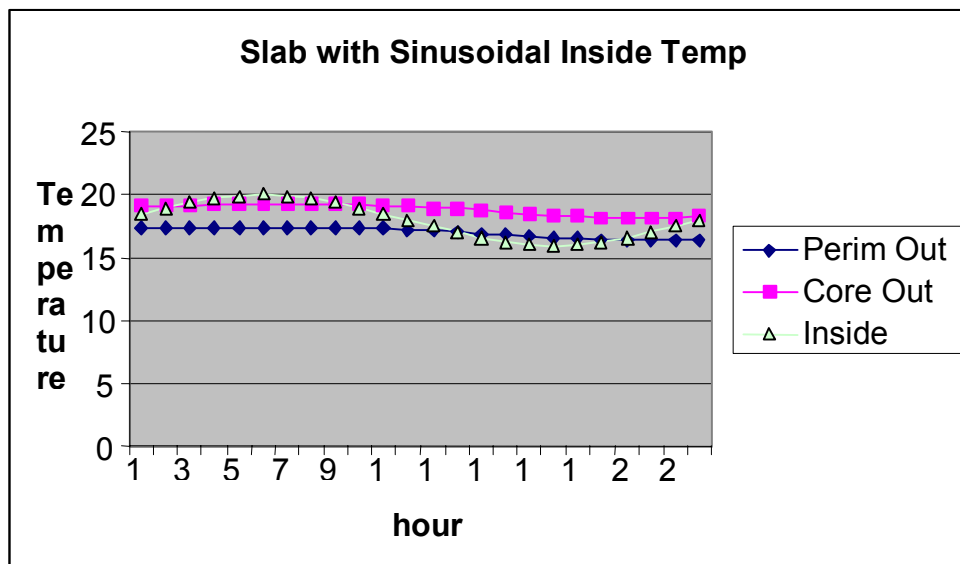
The resulting heat fluxes are shown below.   They can be compared with the fluxes shown above for the constant inside temperature run. The changes resulting from a fairly large 4 C daily temperature variation are probably not significant.

Month	Average	Perimeter	Core	Inside	Perimeter Heat Flux W/m^2	Average Heat Flux W/m^2
1	17.51	16.03	17.86	18	7.30	1.81
2	17.29	15.85	17.63	18	7.96	2.63
3	17.27	16	17.57	18	7.41	2.70
4	18.87	17.77	19.13	20	8.26	4.19
5	19.11	18.16	19.34	20	6.81	3.30
6	19.17	18.34	19.37	20	6.15	3.07
7	20.81	20.07	20.98	22	7.15	4.41
8	21.05	20.36	21.21	22	6.07	3.52
9	21.09	20.38	21.26	22	6.00	3.37
10	21.08	20.19	21.29	22	6.70	3.41
11	19.47	18.45	19.71	20	5.74	1.96
12	19.2	17.92	19.51	20	7.70	2.96

Slab configuration Drawing

The slab configuration used in the slab model is a "slab in grade" model. That is the slab top surface is assumed to be level with the outside earth surface. If a "slab in grade" configuration, having the bottom surface of the slab level with the outside earth surface is desired, the best approximation is to use the horizontal insulation configuration. The edge of the slab will have a small thermal resistance due to the two dimensional path through the earth, but the effect is small. In any case, uninsulated slab edges are certainly not recommended in cold climates.
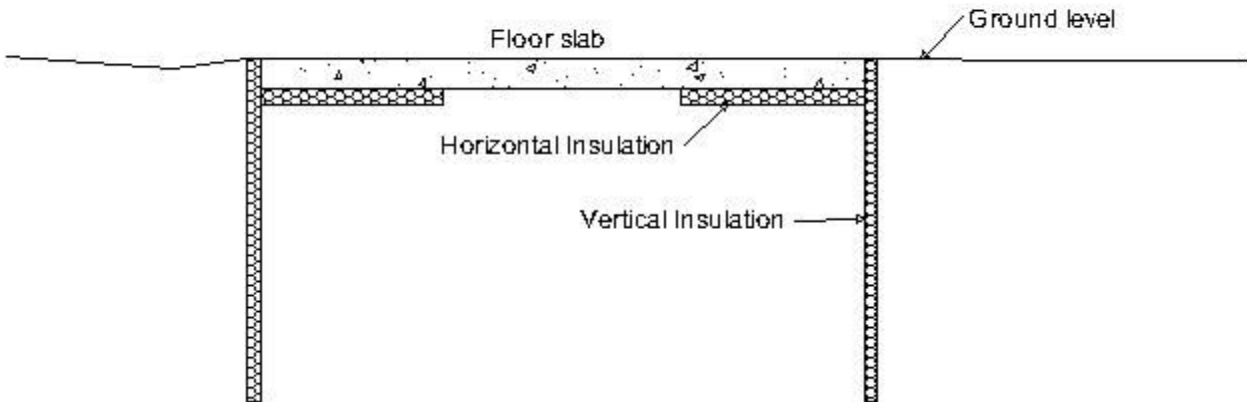
Figure 8. Slab-in-grade illustration

Important Files for Ground Heat Transfer

The slab program used to calculate the results is included with the EnergyPlus distribution. It requires an input file named GHTin.idf in input data file format. The needed corresponding idd file is E+SlabGHT.idd. An EnergyPlus weather file for the location is also needed. A batch file, RunSlab, is placed in the same folder with the program and sample files. To use it (Command mode or DOS mode), one may modify several important lines:

```
:Instructions:
:  Complete the following path and program names.
:  path names must have a following \ or errors will happen
 set program_path=
 set program_name=Slab.exe
 set input_path=
 set output_path=
 set weather_path=C:\EnergyPlus\WeatherData\
```

and then in command mode issue the run command:

```
RunSlab myinput Chicago
```

Where you would have myinput.idf in "input_path" and Chicago would be the name of the .epw file in the "weather_path".

You should set up the command mode so that it does not automatically close the window at the end of program termination if you want to see the commands as they run and know for sure that no errors occurred.

Description of the Objects in the IDD

Materials Object

The materials object gives an overall description of the ground heat transfer model.

Field: NMAT: Number of Materials

This field specifies the number of different materials that will be used in the model. Typically only a ground material and a slab material are used.

Field: Albedo: Surface Albedo: NoSnow

Field: Albedo: Surface Albedo: Snow

Two fields specify the albedo value of the surface. First for no snow coverage days and then for days with snow coverage. The albedo is the solar reflectivity of the surface, and can vary from 0.05 for blacktop to 0.95 for fresh snow. Typical values for North America reported by Bahnfleth range from 0.16 to 0.4.

Field EPSLW: Surface Emissivity: NoSnow

Field EPSLW: Surface Emissivity: Snow

This field specifies the long wavelength (thermal) emissivity of the ground surface. It is primarily important for nighttime radiation to the sky, and a value of 0.95 for both snow and no snow is reasonable.

Field: Z0 Surface Roughness: NoSnow

Field: Z0 Surface Roughness: Snow

These two fields specify a surface roughness that is used in the determination of the convection heat transfer coefficient between the ground surface and the air. This roughness is based on boundary layer considerations, and specifies the height at which an experimentally measured velocity profile goes to zero. The units are centimeters, not meters. Typical values are 0.75 cm for no snow, and 0.05 cm for snow.

Field: HIN: Indoor Hconv: Downward Flow

Field: HIN: Indoor Hconv: Upward Flow

These fields specify the combined convective and radiative heat transfer coefficient between the slab top inside surface and the room air for the cases where heat is flowing downward, and upward. The program toggles between the two if the direction of the heat flux changes. Typical values can be found in the ASHRAE Handbook of Fundamentals, but should be about 6 W/(m^2 K) for downward heat flow and 9 W/(m^2 K) for upward heat flow. The Materials object in the IDD is shown below.

```
Materials,
N1, \field NMAT: Number of materials
    \note typical 2
N2, \field ALBEDO: Surface Albedo: No Snow
    \note typical value= 0.16
N3, \field ALBEDO: Surface Albedo: Snow
    \note typical value= 0.4
N4, \field EPSLW: Surface Emissivity: No Snow
    \note typical value= 0.9
N5, \field EPSLW: Surface Emissivity: Snow
    \note typical value= 0.9
N6, \field Z0: Surface Roughness: No Snow
    \note typical value= 0-10 cm
N7, \field Z0: Surface Roughness: Snow
    \note typical value= 0-10
N8, \field HIN: Indoor HConv: Downward Flow
    \note typical value= 4-10
    \units W/m2-K
N9; \field HIN: Indoor HConv: Upward
    \note typical value= 4-10
    \units W/m2-KMatlProps Object
```

MatlProps

This object contains the material properties that describe the materials used in the model. The fields are quite self explanatory and consist of the following:

Field: RHO: Slab Material Density

Field: RHO: Soil Density

These two fields specify the density of the slab material and the soil in SI units of kg/m3

Field: CP: Slab CP

Field: CP: Soil CP

These two fields specify the specific heat of the slab and soil in SI units of J/(kg-K).

Field: TCON: Slab K

Field: TCON: Soil K

These two fields specify the thermal conductivity of the slab and soil in W/(mK)

The IDD object is shown below:

```
MatlProps,
    N1, \field RHO: Slab Material density
        \note typical value= 2300.0
        \units kg/m3
    N2, \field RHO: Soil Density
        \note typical value= 1200.0
        \units kg/m3
    N3, \field CP: Slab CP
        \note typical value=650.0
        \units J/kg-K
    N4, \field CP: Soil CP
        \note typical value= 1200.0
        \units J/kg-K
    N5, \field TCON: Slab k
        \note typical value= .9
        \units W/m-K
    N6; \field TCON: Soil k
        \note typical value= 1.0
        \units W/m-K
```

BoundConds

This object supplies some of the boundary conditions used in the simulation.

Field: EVTR

This field specifies whether or not to use the evapotransporation model. Evapotransportation comprises all of the processes at the ground surface the involve exchanges of latent heat. The inclusion of evapotransporation in the calculation has the greatest effect in warm dry climates, primarily on the ground surface temperature. This field can be used to turn the evapotransporation off and on to check sensitivity to it.

Field: FIXBC

This field permits using a fixed temperature at the lower surface of the model instead of a zero heat flux condition. This change normally has a very small effect on the results. If the flag is set to use a specified temperature, the program calculates an undisturbed temperature

profile and used the value at the model depth. The model depth is set by the program using the domain size from the EquivAutoGrid object below.

Field: OLDTG

This field should be FALSE. It is better to have the program recalculate the undisturbed ground temperature profile than try to use an existing one. Computation time is very short.

The BoundConds object is shown below:

```
BoundConds,
    A1, \field EVTR: Is surface evapotranspiration modeled
        \type choice
        \key TRUE
        \key FALSE
    A2, \field FIXBC: is the lower boundary at a fixed temperature
        \type choice
        \key TRUE
        \key FALSE
    A3; \field OLDTG: is there an old ground temperature file
        \note Use FALSE -- Don't bother with an old file
        \type choice
        \key TRUE
        \key FALSE
```

BldgProps Object

This object provides information about the building and its operating conditions.

Field: IYRS Number of years to iterate

This field specifies the number of years to iterate. This means that the simulation comes to an either an annual steady periodic condition by converging to a tolerance (see ConvTol field) or it runs for this number of years. A ten year maximum is usually sufficient. It is important to note that the ground heat transfer behavior will change during the first several years of operating a ground contact structure. It takes several years to change from the undisturbed profile to the disturbed profile under a building.

Field: Shape Slab shape

Use only the value 0 here. Only a rectangular shape is implemented.

Field: HBLDG: Building Height

This field supplies the building height. This is used to calculate the building shadowing on the ground. Height is in meters.

Field: TIN1 – TIN12 <month> Indoor Average temperature set point

The next twelve fields specify the average indoor building set point temperatures for each month of the year. These fields are useful for simulating a building that is not temperature controlled for some of the year. In such a case, the average indoor set point temperatures can be obtained by first running the model in EnergyPlus with an insulated floor boundary condition, and then using the resulting monthly average zone temperatures in these fields.

Field: TINAmp: Daily Indoor sine wave variation amplitude

This field permits imposing a daily sinusoidal variation in the indoor setpoint temperature to simulate the effect of a setback profile. The value specified will be the amplitude of the sine wave.

Field: ConvTol: Convergence Tolerance

This final field specifies the convergence tolerance used to control the iteration. When the temperature change of all nodes is less than the convergence value, iteration ceases.

The entire BldgProps Oject is shown below.

```
BldgProps,
      N1, \field IYRS: Number of years to iterate
          \note typical value= 10
      N2, \field Shape: Slab shape
          \note only value= 0
      N3, \field HBLDG: Building height
          \note typical value= 0-20
          \units m
      N4, \field TIN1: January Indoor Average temperature set point
          \note typical value=22
          \units C
      N5, \field TIN2: February Indoor Average temperature set point
          \note typical value=22
          \units C
      N6, \field TIN3: March Indoor Average temperature set point
          \note typical value=22
          \units C
      N7, \field TIN4: April Indoor Average temperature set point
          \note typical value=22
          \units C
      N8, \field TIN5: May Indoor Average temperature set point
          \note typical value=22
          \units C
      N9, \field TIN6: June Indoor Average temperature set point
          \note typical value=22
          \units C
      N10, \field TIN7: July Indoor Average temperature set point
          \note typical value=22
          \units C
      N11, \field TIN8: August Indoor Average temperature set point
          \note typical value=22
          \units C
      N12, \field TIN9: September Indoor Average temperature set point
          \note typical value=22
          \units C
      N13, \field TIN10: October Indoor Average temperature set point
          \note typical value=22
          \units C
      N14, \field TIN11: November Indoor Average temperature set point
          \note typical value=22
          \units C
      N15, \field TIN12: December Indoor Average temperature set point
          \note typical value=22
          \units C
      N16, \field TINAmp: Daily Indoor sine wave variation amplitude
           \note typical value: 0
           \units C
      N17; \field ConvTol: Convergence Tolerance
           \note typical value= 0.1
```

Insulation Object

This object supplies the information about insulation used around the slab. There are two possible configurations: under the slab or vertical insulation around the slab.

Field RINS: R value of under slab insulation

This field provides the thermal resistance value of the under slab insulation. It should be zero if the vertical insulation configuration is selected. Units are m^2 K/W.

Field DINS: Width of strip of under slab insulation

This specifies the width of the perimeter strip of insulation under the slab in meters. Again a zero value should be used for the vertical insulation configuration.

Field RVINS: R value of vertical insulation

This field specifies the thermal resistance of the vertical insulation. It should be zero if the under slab insulation configuration is in effect.

Field ZVINS: Depth of vertical insulation

This field specifies the depth of the vertical insulation into the ground in meters. Note that it starts at the slab upper surface and extends into the ground. Only .2 .4 .6 .8 1.0 1.5 2.0 2.5 or 3.0 m should be used.

Field IVINS: Flag: Is there vertical insulation?

This final field specifies that vertical the vertical insulation configuration is being used. The value of 1 specifies yes and 0 specifies no.

The Insulation object is shown below.

```
Insulation,
    N1, \field RINS: R value of under slab insulation
        \note typical value= 0-2.0
            \units m2-K/W
    N2, \field DINS: Width of strip of under slab insulation
        \note typical value= 0-2.0
        \units m
        N3, \field RVINS: R value of vertical insulation
            \note typical value= 0-3.0
            \units m2-K/W
        N4, \field ZVINS: Depth of vertical insulation
            \note only use values= .2 .4 .6 .8 1.0 1.5 2.0 2.5 3.0
            \units m
        N5; \field IVINS: Flag: Is there vertical insulation?
            \note values: 1=yes 0=no
```

EquivSlab Object

This object provides the basic information for running a model that uses the area over perimeter ratio of the slab to determine the size of an equivalent rectangular slab.

Field APRatio: The area to perimeter ratio for this slab

This field specifies the area over perimeter ratio of the slab in meters.

Field: EquivSizing

This field value should be TRUE. This means that the program will determine the dimensions of the equivalent slab that satisfactorily models the A/P ratio.

The object is shown below.

```
EquivSlab,
\memo Using an equivalent slab allows non-rectangular shapes to be modeled
accurately
```

```
\memo The simulation default should be EquivSizing=True
  N1, \field APRatio: The area to perimeter ratio for this slab
      \units m
  A1; \field EquivSizing:
 \memo Flag: Will the dimensions of an equivalent slab
 \memo be calculated (TRUE) or will the dimensions be input directly? (FALSE)
 \memo It is recommended that EnergyPlus users use TRUE.
```

EquivAutoGrid Object

This object provides the information needed by the program to automatically generate the calculation grid when the slab is described as an equivalent slab. It is necessary for EnergyPlus users because equivalent slab is the appropriate option.

Field SLABDEPTH: Thickness of slab on grade

This field specifies the thickness of the slab in meters. Note that the slab top surface is level with the ground surface, so this is the depth into the ground.

Field CLEARANCE: Distance from edge of slab to domain edge

This field specifies the distance from the slab to the edge of the area that will be modeled with the grid system. It is the basic size dimension that is used to set both the horizontal and vertical extent of the domain. The units are meters, and 15 meters is a reasonable value.

The EquivAutoGrid object is shown below.

```
EquivAutoGrid, \memo  EquivAutoGrid only necessary when EquivSizing is true
               \memo  EnergyPlus users normally use this option.
    N1, \field SLABDEPTH: Thickness of slab on grade
        \note typical value= 0.1
        \units m
    N2; \field CLEARANCE: Distance from edge of slab to domain edge
        \note typical value= 15.0
        \units m
```

Additiional Objects

There are five additional objects in the IDD and IDF that can be used under very special situations by researchers who want to generate special calculation grids. They are normally not useful to EnergyPlus users. They will be shown as IDD sections only. They do not need to be in the IDF.

```
AutoGrid,   \memo AutoGrid only necessary when EquivSizing is false
            \memo  Not normally needed by EnergyPlus users.
    N1, \field SLABX: X dimension of the building slab
        \note typical values= 0-60.0
        \units m
    N2, \field SLABY: Y dimension of the building slab
        \note typical values= 0-60.0
        \units m
    N3, \field SLABDEPTH: Thickness of slab on grade
        \note typical value= .1
        \units m
    N4; \field CLEARANCE: Distance from edge of slab to domain edge
        \note typical value= 15.0
        \units m
!
ManualGrid, \memo Manual Grid only necessary using manual gridding (not
recommended)
            \memo   Used only in special cases.
    N1, \field NX: Number of cells in the X direction
        \note typical values= 15
    N2, \field NY: Number of cells in the Y direction
```

```
        \note typical values= 15
    N3, \field NZ: Number of cells in the Z direction
        \note typical values= 15
    N4, \field IBOX: X direction cell indicator of slab edge
        \note typical values= 1-10
    N5; \field JBOX: Y direction cell indicator of slab edge
        \note typical values= 1-10
!
XFACE,    \memo This is only needed when using manual gridding (not
recommended)
    \memo XFACE: X Direction cell face coordinates: m
    N1, N2, N3, N4, N5, N6, N7, N8, N9, N10, N11, N12, N13, N14,
    N15, N16, N17, N18, N19, N20, N21, N22, N23, N24, N25, N26, N27, N28,
N29,
    N30, N31, N32, N33, N34, N35, N36, N37, N38, N39, N40;
!
YFACE,  \memo This is only needed when using manual gridding (not
recommended)
    \memo YFACE: Y Direction cell face coordinates: m,
    N1, N2, N3, N4, N5, N6, N7, N8, N9, N10, N11, N12, N13, N14,
    N15, N16, N17, N18, N19, N20, N21, N22, N23, N24, N25, N26, N27, N28,
N29,
    N30, N31, N32, N33, N34, N35, N36, N37, N38, N39, N40;
!
ZFACE,  \memo This is only needed when usuing manual gridding (not
recommended)
    \memo ZFACE: Z Direction cell face coordinates: m
    N1, N2, N3, N4, N5, N6, N7, N8, N9, N10, N11, N12, N13, N14,
    N15, N16, N17, N18, N19, N20, N21, N22, N23, N24, N25;
```

Sample IDF File

A sample IDF file is shown below.

```
!-Generator IDFEditor 1.12
!-NOTE: All comments with '!-' are ignored by the IDFEditor and are generated
automatically.
!-      Use '!' comments if they need to be retained when using the
IDFEditor.
!-   ===========  ALL OBJECTS IN CLASS: MATERIALS ===========
Materials,
    2,            !- NMAT: Number of materials
    0.158,        !- ALBEDO: Surface Albedo: No Snow
    0.379,        !- ALBEDO: Surface Albedo: Snow
    0.9,          !- EPSLW: Surface Emissivity: No Snow
    0.9,          !- EPSLW: Surface Emissivity: Snow
    0.75,         !- Z0: Surface Roughness: No Snow
    0.03,         !- Z0: Surface Roughness: Snow
    6.13,         !- HIN: Indoor HConv: Downward Flow {W/m2-K}
    9.26;         !- HIN: Indoor HConv: Upward {W/m2-K}


!-   ===========  ALL OBJECTS IN CLASS: MATLPROPS ===========

MatlProps,
    2300,         !- RHO: Slab Material density {kg/m3}
    1200,         !- RHO: Soil Density {kg/m3}
    653,          !- CP: Slab CP {J/kg-K}
    1200,         !- CP: Soil CP {J/kg-K}
    0.93,         !- TCON: Slab k {W/m-K}
    1;            !- TCON: Soil k {W/m-K}
```

```
!-   ==========   ALL OBJECTS IN CLASS: BOUNDCONDS   ==========


BoundConds,
    TRUE,           !- EVTR: Is surface evapotranspiration modeled
    TRUE,           !- FIXBC: is the lower boundary at a fixed temperature
    FALSE;          !- OLDTG: is there an old ground temperature file



!-   ==========   ALL OBJECTS IN CLASS: BLDGPROPS   ==========

BldgProps,
    10,             !- IYRS: Number of years to iterate
    0,              !- Shape: Slab shape
    4,              !- HBLDG: Building height {m}
    18,             !- TIN1: January Indoor Average temperature set point {C}
    18,             !- TIN2: February Indoor Average temperature set point {C}
    18,             !- TIN3: March Indoor Average temperature set point {C}
    20,             !- TIN4: April Indoor Average temperature set point {C}
    20,             !- TIN5: May Indoor Average temperature set point {C}
    20,             !- TIN6: June Indoor Average temperature set point {C}
    22,             !- TIN7: July Indoor Average temperature set point {C}
    22,             !- TIN8: August Indoor Average temperature set point {C}
    22,             !- TIN9: September Indoor Average temperature set point {C}
    22,             !- TIN10: October Indoor Average temperature set point {C}
    20,             !- TIN11: NovemberIndoor Average temperature set point {C}
    20,             !- TIN12: December Indoor Average temperature set point {C}
    0,              !- TINAmp: Daily sine wave variation amplitude {C}
    0.10;           !- ConvTol: Convergence Tolerance



!-   ==========   ALL OBJECTS IN CLASS: INSULATION   ==========

Insulation,
    0.,             !- RINS: R value of under slab insulation {m2-K/W}
    0.,             !- DINS: Width of strip of under slab insulation {m}
    2.0,            !- RVINS: R value of vertical insulation {m2-K/W}
    2.0,            !- ZVINS: Depth of vertical insulation {m}
    1;              !- IVINS: Flag: Is there vertical insulation



!-   ==========   ALL OBJECTS IN CLASS: EQUIVSLAB   ==========

EquivSlab,
    10,             !- APRatio: The area to perimeter ratio for this slab {m}
    TRUE;           !- EquivSizing:



!-   ==========   ALL OBJECTS IN CLASS: EQUIVAUTOGRID   ==========

EquivAutoGrid,
    0.1,            !- SLABDEPTH: Thickness of slab on grade {m}
    15;             !- CLEARANCE: Distance from edge of slab to domain edge {m}



!-   ==========   ALL OBJECTS IN CLASS: AUTOGRID   ==========

AutoGrid,
    12,             !- SLABX: X dimension of the building slab {m}
    12,             !- SLABY: Y dimension of the building slab {m}
    0.1,            !- SLABDEPTH: Thickness of slab on grade {m}
    15;             !- CLEARANCE: Distance from edge of slab to domain edge {m}
```

References

Bahnfleth, W.P. 1989. Three Dimensional Modeling of Heat Transfer from Slab Floors. Ph.D. diss., also published as USACERL TM E-89/11, University of Illinois.

Bahnfleth, W.P. and C.O. Pedersen. 1990. A Three Dimensional Numerical Study of Slab-on-Grade Heat Transfer. ASHRAE Transactions Pt. 2, 96:61-72.

Clements, Edward, 2003, Three Dimensional Foundation Heat Transfer Modules for Whole-Building Energy Analysis, MS Thesis, Pennsylvania State University.

VCompare

In a perfect world, each developer change to the Data Dictionary/Object structure would be upwards compatible from the previous version. And, we are reaching toward that goal, but not quite there yet.

A small program "VCompare" (Energy+.idd Version Compare) has been developed that can highlight the differences in two Energy+.idd files for you. Though it will be presented as a user tool, it is most likely of more use to the Interface Developers that will be creating the input files of the future.

Though in its release form, it will be used to highlight differences between the last release of EnergyPlus and the current release, it can be used anywhere in a development as well. We in the EnergyPlus development team have found it very useful during the march to the 1.0.1 release.

As an additional utility feature, VCompare can create new IDFs using the differences between the two IDDs. Though this is not the preferred method for release conversions (see next section in this document), it can be used as desired. The following instructions describe the usage of VCompare.

Each release will also have an Objstats.xls file (see below) that will have formatting and comments from the equivalent objstats.csv file that is produced when VCompare is run.

VCompare Usage

The VCompare.exe is a utility program to help you transform any files from your previous version of EnergyPlus to the new object definitions for EnergyPlus 1.0.1. It needs an "old" IDD and a "new" IDD in order to run. It can be run interactively (just execute Vcompare), with a file (i.e. VCompare <filename>) or it can accept a file name as the input to the first question if you put an @ in front. @MyTests.in

It uses the standard Energy+.ini file to determine locations and where to leave the objstats.csv file.

Here is an example file that it could use (do not use the "line<x>: " as part of the file):

```
line1: 'e:\eplus\V1-0-0energy+.idd'
line2: 'e:\eplus\energy+.idd'
line3: diff
line4: yes
line5: 2826-TermReheatOA-MisMatch2.idf
as many files as you would like to "change".
```

V1-0-0energy+.idd is a specially changed version of the energy+.idd for EnergyPlus 1.0.0 that will produce minimal "problems" in the resultant changed files. (There have been some field name changes and some units changes, for example. Sometimes in the same field!)

line3: diff -- you can put "diff" or "full" here. Diff will give you a resultant file of only "different" objects in your given input files. "Full" will put out a full new version (with field comment lines). However, "full" does not preserve any "sections" that were in the previous idf file.

line4: yes -- you can put "yes" or "no" here. Yes will put units on appropriate lines in the new files, no does not.

line5, succeeding. For each file you list here (assuming it will pass the parse of the "old" IDD), you will get two files: <filename>.err and <filename>.difnew The .err file should be empty. The .difnew file is what you want. It contains the "changed" objects from the old IDD to the new IDD. In the same order as the original file.

You also get a objstats.csv file as a result. This should contain the same information as in the ObjectStatus.xls file that is included above. By the way, you could also use the same IDDs for both OLD and NEW as well as "full" to get completely annotated input files. (No guarantees!)

Table 16. VCompare Output Files and Descriptions

VCompare Output File Name	Description
Eplusout.err	Will only occur if there are problems with the two IDDs being compared. This file will show up in the program directory (from the Energy+.ini directions).
Objstats.csv	Differences between objects in the two IDDs. (Same objects are not shown).
<filename>.difnew	Results for each <filename> entered. This will be a full IDF file if "full" is entered or only those objects that are different when "diff" is entered.
<filename>.Vcperr	Errors, if any, on the <filename>.idf or conversion.

Examples of changed "objects" in the .difnew file:

```
This object has the status of "diff # fields".
Note the names and units of each field.
 ! Diff # Fields
 CHILLER:CONST COP,
   Little Chiller,  !- Chiller Name
   25000,  !- Nominal Capacity {W}
   2.5,  !- COP
   ,  !- Design Evaporator Volumetric Water Flow Rate {m3/s}
   0.0011,  !- Design Condenser Volumetric Water Flow Rate {m3/s}
   Little Chiller Inlet Node,  !- Plant_Side_Inlet_Node
   Little Chiller Outlet Node,  !- Plant_Side_Outlet_Node
   Little Chiller Condenser Inlet Node,  !- Condenser_Side_Inlet_Node
   Little Chiller Condenser Outlet Node,  !- Condenser_Side_Outlet_Node
   AIR COOLED,  !- Condenser Type
   VariableFlow;  !- Chiller Flow Mode
```

In the above, we have an added field (Design Evaporator Volumetric Water Flow Rate). It is blank in the new .difnew version -- but probably needs a value before you just run it through EnergyPlus!

Here's a couple more. To illustrate how "units change" show:

```
 ! Units Change
 COIL:Water:SimpleHeating,
   Bldg-A Reheat Coil Zone 3,  !- Coil Name
   Bldg-A FanAndCoilAvailSched,  !- Available Schedule
   400.0,  !- UA of the Coil {W/K}
!***! Units Change, next field=kg/s -> m3/s {old value in old units shown}
   1.8,  !- Max Water Flow Rate of Coil {m3/s}
   Bldg-A Zone 3 Reheat Water Inlet Node,  !- Coil_Water_Inlet_Node
   Bldg-A Zone 3 Reheat Water Outlet Node,  !- Coil_Water_Outlet_Node
   Bldg-A Zone 3 Reheat Air Inlet Node,  !- Coil_Air_Inlet_Node
   Bldg-A Zone 3 Reheat Air Outlet Node;  !- Coil_Air_Outlet_Node
```

```
 ! #Fields+Field Name Chg+Units Change
 CONTROLLER:SIMPLE,
   Bldg-A Main Cooling Coil Controller,  !- Name
   TEMP,  !- Control variable
   Reverse,  !- Action
   FLOW,  !- Actuator variable
   Bldg-A Air Loop Outlet Node,  !- Control_Node
   Bldg-A Cooling Coil Water Inlet Node,  !- Actuator_Node
   0.1,  !- Controller Convergence Tolerance: delta temp from setpoint {C}
!***! Units Change, next field=kg/s -> m3/s {old value in old units shown}
   1.1,  !- Max Actuated Flow {m3/s}
!***! Units Change, next field=kg/s -> m3/s {old value in old units shown}
   0.0;  !- Min Actuated Flow {m3/s}
```

Note that the "Units" comment -- "!***! Units Change, next field=kg/s -> m3/s {old value in old units shown}" shows the value (e.g. 1.1) as it originally appeared in your input file and these are in the old units whereas the rest of the line may show the new units for the field (if you chose to have units listed in the new fields.

Note that the IDF files converted will have the new (dif and err) files placed in the original folder that the IDF came from. To use the new IDF (full command), just change the extension on the difnew file to IDF (personally, I'd back up the old IDF first) and run EnergyPlus. If you choose the "diff" option, you will have to cut and paste into the IDF. Note that any comments from the original IDF are not carried over.

At this time, the VCompare program is not capable of accepting EP-Macro enabled files and will probably choke on any "##" commands – of course, an excerpt IDF file will be readily accepted and converted to a new excerpt IDF.

Transition_Vold_Vnew

While VCompare is very useful, it still leaves quite a bit of work for the user to transition from one release version to the next. To help overcome this burden on the user, the Transition_Vold_Vnew is created.

> Note that Transition_Vold_Vnew is a generic way of naming the program. The actual program from release to release will vary.

TransitionV1-0-0-to-V1-0-1.exe is the current transition program that will be distributed with the V1.0.1 release. It uses several important files that are included in the main "EnergyPlus" folder.

File Name	Description
V1-0-0Energy+.idd	Version 1.0.0 release Energy+.idd file
V1-0-1Energy+.idd	Identical to Energy+.idd when distributed
Report Variables 1-0-0-023 to 1-0-1.csv	Report variable name changes

Another file "Rules1-0-0to1-0-1.xls" is not used directly by the program but contains the "rules" for translating objects from version 1.0.0 release to the 1.0.1 release.

The report variables conversion is not quite "perfect" but (hopefully) close. For example, many new fuel types were added so that now one might have a Gas, Electric, or Fuel Oil#1 Boiler. The old "Fuel Consumption" report variable, in this case, should get transferred to the new Boiler <fuel> Consumption but the Transition program isn't smart enough to know what kind of fuel your boiler is using to it transforms to the "Boiler Gas Consumption" variable. If, in fact, you have a different fuel for your boiler, you will receive a warning message that Boiler Gas Consumption does not apply in the **eplusout.err** file. Just revise these kinds of variable names to the proper fuel. Several other components will also exhibit this kind of translation problem.

As you will see if you examine the "rules" spreadsheet, some things just can't be converted. In these instances, a warning message is issued (see output files below) and that same warning will also appear on the screen. In most instances, there will be an equivalent IDF comment before the "offending" object and the field inserted will be an indicator that something is incorrect in the translation.

For the transition program, the IDD names are "hard-wired" – and the program uses the location from the Energy+.ini file to determine where to find them. In other regards, it is very similar to the Vcompare program described in the previous section.

Note that the IDF files converted will have the new (dif and err) files placed in the original folder that the IDF came from. To use the new IDF (full command), just change the extension on the difnew file to IDF (personally, I'd back up the old IDF first) and run EnergyPlus. If you choose the "diff" option, you will have to cut and paste into the IDF. Note that any comments from the original IDF are not carried over.

At this time, the Transition program is not capable of accepting EP-Macro enabled files and will probably choke on any "##" commands – of course, an excerpt IDF file will be readily accepted and converted to a new excerpt IDF.

Table 17. Transition Output Files and Descriptions.

Transition Output File Name	Description
Eplusout.err	Will only occur if there are problems with the two IDDs being compared. This file will show up in the program directory (from the Energy+.ini directions). ***Should not happen!***
Objstats.csv	Differences between objects in the two IDDs. (Same objects are not shown).
<filename>.difnew	Results for each <filename> entered. This will be a full IDF file if "full" is entered or only those objects that are different when "diff" is entered.
<filename>.Vcperr	Errors, if any, on the <filename>.idf or conversion.

HVAC System Templates

HVAC system templates provide a shorthand way of describing selected standard HVAC system configurations. Available templates include:

- Zone Thermostat

- Purchased Air

- Four Pipe Fan Coil

- VAV Single Duct with Reheat

- Packaged Furnace with DX Air Conditioner

- Purchased Hot Water and Chilled Water Supply Loop

- Single Boiler Supply Loop

- Single Chiller Supply Loop

- Multiple equipment supply loop (boilers or chillers)

- Multiple equipment condenser loop

Template Structure and Usage

Overall Template Structure

The templates utilize input macros (see the Input Output Reference, Appendix C) to provide a short-hand way to describe a standard HVAC system configuration. Note that the EnergyPlus input file will be an "imf" file rather than an "idf" file, because it will contain input macro commands. (See Appendix C for more details about input macros.) For example, the EnergyPlus objects required to describe the zone equipment for a zone with Purchased Air are shown below:

```
CONTROLLED ZONE EQUIP CONFIGURATION,
      RESISTIVE ZONE, ! zone name
      RESISTIVE ZONE Equipment, ! zone equipment list
      RESISTIVE ZONE Inlets, ! inlet node list
                     , ! exhaust node list
      RESISTIVE ZONE ZoneNode, ! zone node
      RESISTIVE ZONE Outlet Node; ! zone outlet node

   ZONE EQUIPMENT LIST,
      RESISTIVE ZONE Equipment, ! name
      PURCHASED AIR, RESISTIVE ZONE PurchasedAir, 1, 1;

   NODE LIST,
      RESISTIVE ZONE Inlets, ! name
      RESISTIVE ZONE PurchAirOutletNode; ! the zone inlet is the fancoil air
outlet

   PURCHASED AIR,
      RESISTIVE ZONE PurchasedAir , ! Name
      RESISTIVE ZONE PurchAirOutletNode , ! Zone Supply Air Node Name
      50 , ! Heating Supply Air Temp
      13 , ! Cooling Supply Air Temp
      0.015 , ! Heating Supply Air Humidity Ratio
      0.010 ; ! Cooling Supply Air Humidity Ratio
```

Using the template language, the following input produces the same set of objects:

```
##set1 ZoneName         = "RESISTIVE ZONE"
##set1 AvailSched       = "FanAndCoilAvailSched"
##set1 HeatSuppAirTemp  = 50
##set1 CoolSuppAirTemp  = 13
##set1 HeatSuppAirHR    = 0.015
##set1 CoolSuppAirHR    = 0.010
PurchAirZone[]
```

The example above illustrates the basic way in which the templates are used:

■ First, the required macro variables are assigned using the ##set1 command.

■ Then a macro is invoked with no formal parameters passed to it. Each macro expects a certain set of macro variables to be defined and substitutes their values into the appropriate places in the expanded objects.

The overall flow when using the HVAC templates is shown in Figure 9. EP-Launch and RunEplus.bat will automatically execute EP-Macro when the input file extension is IMF. The full set of EP-Macro commands are explained in a later section in this document (see: Input Macros). However, the few commands required to use the HVAC templates are also explained in this section.
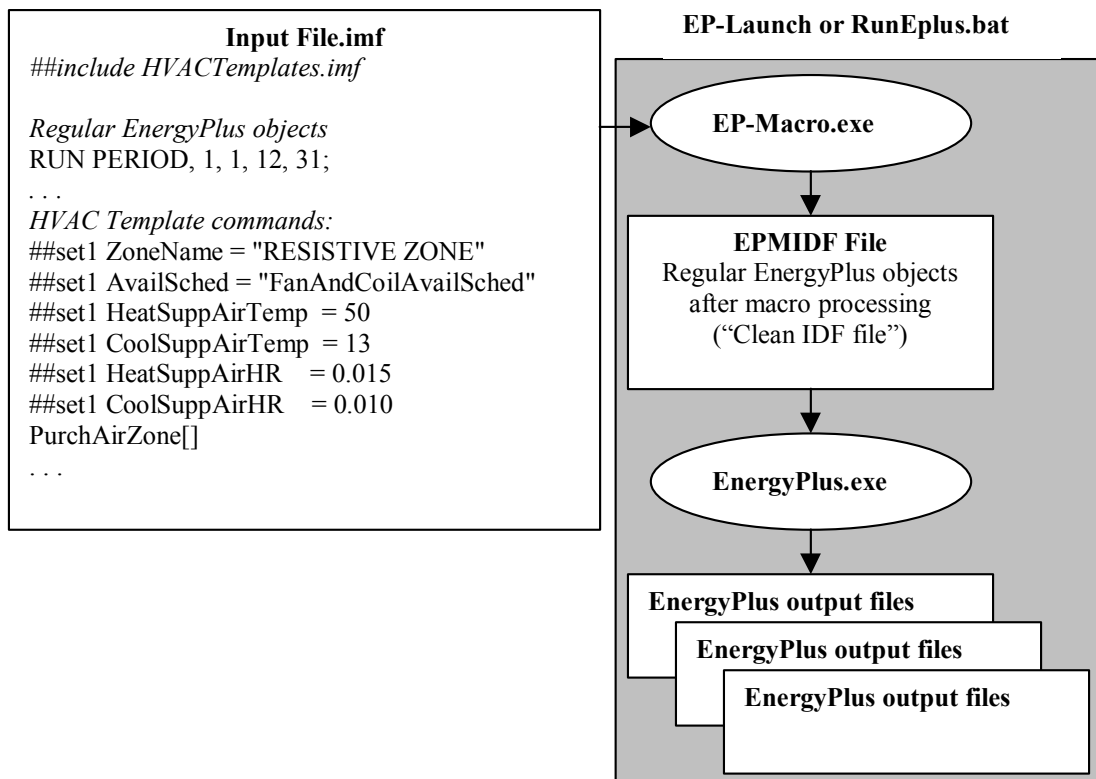

Figure 9. HVAC Template Structure

The input file (imf extension) contains both regular EnergyPlus objects and HVAC template commands. EP-Launch, or the RunEPlus.bat batch file executes EP-Macro.exe which processes the HVAC template commands and produces a clean input file (epmidf extension)

containing only regular EnergyPlus objects. Then EnergyPlus.exe is run to produce the usual output files.

Using the Templates as a Pre-Processing Tool

Most users will use the templates as a preliminary step to create a set of HVAC system objects which will then be added to an existing idf file containing a building envelope description. The following steps describe how to use the templates in this fashion:

1. Create a short imf input file containing only the HVAC description using the HVAC template commands.

2. Run a simulation using the imf file. EP-macro will process the template commands and EnergyPlus will try to run the file, but it will fail, because it is an incomplete file with no building description.

3. Review the EP-macro output file (epmdet) for errors. Correct and repeat Step 2, if needed.

4. The resulting epmidf file will contain a clean set of idf objects describing the HVAC system. Using a text editor, these objects can then be pasted into the main idf file containing the building description and the rest of the input for the project.

Advantages of this approach are that the full set of HVAC objects can be seen and further edited directly using the IDF Editor or a text editor. Disadvantages are that any major changes to the HVAC system (such as adding another zone) would require repeating these steps to merge a new HVAC system into the main input file.

Using the Templates Directly in the Input File

Some users will user the templates in their main input file, which must then be an imf file. Advantages are that changes can be made to the HVAC description without repeating the steps above to merge a new set of HVAC objects with the building description. Disadvantages are that the input is less clear and the IDF Editor cannot be used to edit the input file.

Autosized vs. Fully Specified Template Commands

There are two sets of HVAC template commands:

- HVACTemplates.imf contains "fully specified" template commands. The commands require that the user set all equipment size, performance, and control specifications.

- HVACTemplates-Autosize.imf contains simplified template commands which autosize all equipment and use default performance and control specifications wherever possible. The commands require the minimum possible user inputs to define an HVAC system. All macro commands names in this file end with "-Autosize".

Since most users will likely use only one set in a given simulation, the commands have been separated into two files in order to reduce the EP-macro processing time. The user must "include" the applicable template command file (see below) in order to make the desired set of commands available. It is possible to use both in the same input file if desired.

Template Commands

BasicCommands

The following macro language commands are required in order to use the HVAC Templates:

- **##fileprefix <path>**
  Sets the path to where the master template definition file is located

- **##includesilent HVACTemplates.imf or**
  ##includesilent HVACTemplates-Autosize.imf
  Includes the template definition file into the input stream without echoing it to the epmdet file.

- **##set1 VariableName <Value>**
  Sets macro variable "VariableName" to "Value"

- **MacroName[]**
  Invokes a multi-line macro to insert a block of EnergyPlus objects into the input stream.

The commands listed above are the only required commands, but the entire set of EP-Macro commands may be used both in managing the HVAC template inputs or elsewhere in the input file.

Syntax Rules

The following rules must be adhered to in order for the HVAC template macros to process correctly:

- Macro variable names are case insensitive, so ##set1 ZoneName and ##set1 zonename are equivalent.

- System macro names are invoked after the required input variables have been set.

- System macro names must be followed by [ ] in order to identify the name as a macro.

- All strings must be enclosed in double quotes "String".

- Strings for inputs other than zone and system names may contain only letters, numbers and dashes "-". *They may <u>not</u> contain spaces or other special characters.*

- Zone names and system names are limited to 32 characters *(Note this is less than the EnergyPlus name limit of 60 characters, because internal names are appended to the zone names and system names to create unique names for equipment objects and system nodes.)*

- Schedule names are limited to 60 characters, the standard EnergyPlus limit.

- EnergyPlus is initially limited to 50 components per splitter or mixer. Due to this limit, air handling systems may serve up to 50 zones per primary air loop, and chilled/hot water loops may serve a maximum of 50 coils each. If the system has zonal water coils (such as reheat coils or fan coils) then a given water loop would be limited to serving up to 50 zones. If the air handlers have only central coils (one heating coil and one cooling coil per air handler), then a given water loop could serve up to 50 air handlers which serve up to 50 zones each, for a total limit of 2500 zones. These limits can be overridden by editing the IDD file, and the HVAC templates master macro file would also need editing.

- It is safest to reassign all required input variables prior to every macro call, even if they are assigned the same value as in the previous call. Macro variable definitions are not reset after a macro is called, so if a variable is not assigned a new value before a later call to the same macro, the old value will be used without warning. If the same value will be applied to several zones, for example, it is possible to set a variable once for the first zone and not repeat it for the later zones.

Example Files

In the EnergyPlus\Templates folder, there are example imf files which illustrate the use of the template macro commands. Some of these examples have equivalent idf files in the EnergyPlus\Examples folder, such as PurchAir-TE.imf and PurchAir.idf.

HVAC IDF Segments

In the EnergyPlus\Templates\HVAC IDF Segments folder, there are idf file segments which contain full idf objects for particular system portions. For example, BoilerSupply-01 contains a boiler supply loop with a single boiler. BoilerSupply-02 contains a boiler supply loop with two boilers, and so on up to BoilerSupply-10. The file segments have been set to autosize wherever possible. Using these file segments provides a quick way to add the necessary objects to an idf file, but will almost always require further editing of names, equipment types, sizes, zone names, etc. To substitute different types of equipment into these idf segments, be sure to keep the node names the same, and search for all occurrences of the equipment type and name.

Describing Typical HVAC Systems Using the HVAC Templates

To describe typical HVAC system configurations, a combination of system macro commands is used along with the required macro variable definitions prior to each command. The commands required for several typical HVAC systems are listed below. Many of the system template commands are available in two versions, one with autosizing and defaults and one where the user specifies all required sizing and control information. These examples here use the autosize versions.

Purchased Air System

ZoneThermostat[ ] (once for each zone)

PurchAirZone-Autosize[ ] (once for each zone)

Packaged Furnace with DX Cooling System

ZoneThermostat[ ] (once for each zone)

DirectAirZone-Autosize[ ] (once for each zone)

UnitaryAirLoop-Autosize[ ]

Four-Pipe Fan Coil System

ZoneThermostat[ ] (once for each zone)

4PipeFanCoilZone-Autosize[ ] (once for each zone)

FanCoilLoops-Autosize[ ]

Single-Duct VAV System with Outside Air Option

ZoneThermostat[ ] (once for each zone)

VAVZone-Autosize[ ] (once for each zone)

VAVAirLoop-Autosize[ ]

ChilledWaterDemand-Autosize[ ]

HotWaterDemand-Autosize[ ]

Purchased Hot Water/Chilled Water Supply Plant

PurchasedSupplyWithBypass-Autosize[ ]

Single Chiller Supply Plant

ChillerSupply1-Autosize [ ]

Condenser1-Autosize[ ]

Single Boiler Supply Plant

BoilerSupply1-Autosize [ ]

System Macro Commands

Each available system macro command is described below including descriptions of the parameters which must be set prior to invoking the macro, an example of the macro inputs, and a list of the EnergyPlus objects which are generated by the macro. Many of the parameters are equivalent to a specific field in a standard EnergyPlus object, so the parameter description may reference a standard object name for more explanation.

ZoneThermostat-Autosize[ ] and ZoneThermostat

These two commands are identical.

Describes the thermostatic temperature controls for one zone.

ZoneName

The name of the zone to be controlled by this thermostat.

ZoneCtrlSched

The zone control type schedule name. See ZONE CONTROL:THERMOSTATIC for more explanation.

SnglHeatSPSched

The single heating setpoint schedule name. Schedule values are in [C]. If this control type is not used, then this should be set to "None". See SINGLE HEATING SETPOINT for more explanation.

SnglCoolSPSched

The single cooling setpoint schedule name. Schedule values are in [C]. If this control type is not used, then this should be set to "None". See SINGLE COOLING SETPOINT for more explanation.

SnglHtClSPSched

The single heating/cooling setpoint schedule name. Schedule values are in [C]. If this control type is not used, then this should be set to "None". See SINGLE HEATING COOLING SETPOINT for more explanation.

DualSPHeatSched

The dual setpoint heating setpoint schedule name. Schedule values are in [C]. If this control type is not used, then this should be set to "None". See DUAL SETPOINT WITH DEADBAND for more explanation.

DualSPCoolSched

The dual setpoint cooling setpoint schedule name. Schedule values are in [C]. If this control type is not used, then this should be set to "None". See DUAL SETPOINT WITH DEADBAND for more explanation.

```
! Zone Thermostat Parameters (used by ZoneThermostat[])
##set1 ZoneName         = "RESISTIVE ZONE"          ! Zone name
##set1 ZoneCtrlSched    = "Zone-Control-Type-Sched" ! Zone-Control-Type-Schedule
##set1 SnglHeatSPSched  = "Heating-Setpoints"       ! Single Heating Setpoint Schedule
##set1 SnglCoolSPSched  = "Cooling-Setpoints"       ! Single Cooling Setpoint Schedule
##set1 SnglHtClSPSched  = "None"                    ! Single Heating/Cooling Setpoint Schedule
##set1 DualSPHeatSched  = "None"                    ! Dual Setpoint Heating Setpoint Schedule
##set1 DualSPCoolSched  = "None"                    ! Dual Setpoint Cooling Setpoint Schedule

ZoneThermostat[]
```

Objects generated:

ZONE CONTROL:THERMOSTATIC

SINGLE HEATING SETPOINT

SINGLE COOLING SETPOINT

SINGLE HEATING COOLING SETPOINT

DUAL SETPOINT WITH DEADBAND

PurchAirZone-Autosize[ ] and PurchAirZone[ ]

Describes the zone equipment for one purchased air zone.

The following parameters are required for both commands:

ZoneName

The name of the zone to be served by this purchased air unit.

The following parameters are required only for the non-autosize command:

HeatSuppAirTemp

The heating supply air temperature in [C]. See PURCHASED AIR for more explanation.

CoolSuppAirTemp

The cooling supply air temperature in [C]. See PURCHASED AIR for more explanation.

HeatSuppAirHR

The heating supply air humidity ratio in [kg-H20/kg-air]. See PURCHASED AIR for more explanation.

CoolSuppAirHR

The cooling supply air humidity ratio in [kg-H20/kg-air]. See PURCHASED AIR for more explanation.

```
! Purchased Air Parameters (used by PurchAirZone[])
##set1 ZoneName         = "RESISTIVE ZONE"              ! Zone name
##set1 HeatSuppAirTemp  = 50                            ! Heating Supply Air Temp [C]
##set1 CoolSuppAirTemp  = 13                            ! Cooling Supply Air Temp [C]
##set1 HeatSuppAirHR    = 0.015                         ! Heating Supply Air Humidity Ratio [kg-H20/kg-air]
##set1 CoolSuppAirHR    = 0.010                         ! Cooling Supply Air Humidity Ratio [kg-H20/kg-air]

PurchAirZone[]
```

Objects generated:

CONTROLLED ZONE EQUIP CONFIGURATION

ZONE EQUIPMENT LIST

NODE LIST

PURCHASED AIR

4PipeFanCoilZone-Autosize [ ] and 4PipeFanCoilZone[ ]

Describes the zone equipment and demand-side branches for one zone on a four pipe fan coil system.

The following parameters are required for both commands:

ZoneName

The name of the zone to be served by this fan coil unit.

AvailSched

Availability schedule name for this fan coil unit.

HeatAvailSched

Availability schedule name for the heating coil in this fan coil unit.

CoolAvailSched

Availability schedule name for the cooling coil in this fan coil unit.

The following parameters are required only for the non-autosize command:

ZoneSuppAirFlow

Zone supply air flow rate [m3/s]. See FAN COIL UNIT:4 PIPE for more explanation.

ZoneOutAirFlow

Zone outside air flow rate [m3/s]. See FAN COIL UNIT:4 PIPE for more explanation.

ZoneMaxChWFlow

Zone maximum chilled water flow rate [m3/s]. See FAN COIL UNIT:4 PIPE for more explanation.

ZoneMinChWFlow

Zone minimum chilled water flow rate [m3/s]. See FAN COIL UNIT:4 PIPE for more explanation.

ZoneChWTolerance

Zone tolerance on chilled water control [C]. See FAN COIL UNIT:4 PIPE for more explanation.

ZoneMaxHWFlow

Zone max hot water flow rate [m3/s]. See FAN COIL UNIT:4 PIPE for more explanation.

ZoneMinHWFlow

Zone min hot water flow rate [m3/s]. See FAN COIL UNIT:4 PIPE for more explanation.

ZoneHWTolerance

Zone tolerance on hot water control [C]. See FAN COIL UNIT:4 PIPE for more explanation.

ZoneFanEffic

Zone fan total efficiency. See FAN:SIMPLE:ConstVolume for more explanation.

ZoneFanPressure

Zone fan pressure rise [Pa]. See FAN:SIMPLE:ConstVolume for more explanation.

ZoneFanMtrEffic

Zone fan motor efficiency. See FAN:SIMPLE:ConstVolume for more explanation.

ZoneFanMtrInAir

Zone fan motor in air stream fraction. See FAN:SIMPLE:ConstVolume for more explanation.

ZoneCoolCoilUA

Zone cooling coil UA [W/K]. See COIL:Water:SimpleCooling for more explanation.

ZoneCoolCoilLvRH

Zone cooling coil leaving air relative humidity. See COIL:Water:SimpleCooling for more explanation.

ZoneHeatCoilUA

Zone heating coil UA [W/K]. See COIL:Water:SimpleHeating for more explanation.

```
##set1 ZoneName         = "RESISTIVE ZONE"         ! Zone name
##set1 AvailSched       = "FanAndCoilAvailSched"     ! Availability schedule
##set1 ZoneSuppAirFlow  = 0.84     ! Zone supply air flow rate [m3/s]
##set1 ZoneOutAirFlow   = 0.05     ! Zone outside air flow rate [m3/s]
##set1 ZoneMaxChWFlow   = 0.0010   ! Zone max chilled water flow rate [m3/s]
##set1 ZoneMinChWFlow   = 0.0      ! Zone min chilled water flow rate [m3/s]
##set1 ZoneChWTolerance = 0.001    ! Zone tolerance on chilled water control [C]
##set1 ZoneMaxHWFlow    = 0.0005   ! Zone max hot water flow rate [m3/s]
##set1 ZoneMinHWFlow    = 0.0      ! Zone min hot water flow rate [m3/s]
##set1 ZoneHWTolerance  = 0.001    ! Zone tolerance on hot water control [C]
##set1 ZoneFanEffic     = 0.5      ! Zone fan total efficiency
##set1 ZoneFanPressure  = 75.0     ! Zone fan pressure rise [Pa]
##set1 ZoneFanMtrEffic  = 0.9      ! Zone fan motor efficiency
##set1 ZoneFanMtrInAir  = 1.0      ! Zone fan motor in air stream fraction
##set1 ZoneCoolCoilUA   = 600.0    ! Zone cooling coil UA [W/K]
##set1 ZoneCoolCoilLvRH = 0.9      ! Zone cooling coil leaving air relative humidity
##set1 ZoneHeatCoilUA   = 400.0    ! Zone heating coil UA [W/K]

4PipeFanCoilZone[]
```

Objects generated:

OUTSIDE AIR INLET NODE LIST

CONTROLLED ZONE EQUIP CONFIGURATION

ZONE EQUIPMENT LIST

NODE LIST

FAN COIL UNIT:4 PIPE

OUTSIDE AIR MIXER

FAN:SIMPLE:ConstVolume

COIL:Water:SimpleCooling

COIL:Water:SimpleHeating

BRANCH

VAVZone-Autosize[ ] and VAVZone[ ]

Describes the zone equipment and demand-side branches for one zone on a single duct VAV reheat system.

The following parameters are required for both commands:

ZoneName

Zone name

AvailSched

Availability schedule name for this VAV terminal unit.

The following parameters are required only for the non-autosize command:

ZoneSuppAirFlow

Zone supply air flow rate [m3/s] at full flow. See SINGLE DUCT:VAV:REHEAT for more explanation.

ZoneMinAirFrac

Zone minimum supply air flow fraction. See SINGLE DUCT:VAV:REHEAT for more explanation.

ZoneMaxHWFlow

Zone max reheat hot water flow rate [m3/s]. See SINGLE DUCT:VAV:REHEAT for more explanation.

ZoneMinHWFlow

Zone min reheat hot water flow rate [m3/s]. See SINGLE DUCT:VAV:REHEAT for more explanation.

ZoneHWTolerance

Zone tolerance on hot water control [C]. See SINGLE DUCT:VAV:REHEAT for more explanation.

ZoneHeatCoilUA

Zone heating coil UA [W/K] . See COIL:WATER:SIMPLEHEATING for more explanation.

```
##set1 ZoneName        = "RESISTIVE ZONE"           ! Zone name
##set1 AvailSched      = "FanAndCoilAvailSched"     ! System Availability Schedule
##set1 ZoneSuppAirFlow = 0.47                       ! Zone supply air flow rate [m3/s]
##set1 ZoneMinAirFrac  = 0.3                        ! Zone min supply air flow fraction
##set1 ZoneMaxHWFlow   = 0.0013                     ! Zone max reheat hot water flow rate [m3/s]
##set1 ZoneMinHWFlow   = 0.0                        ! Zone min reheat hot water flow rate [m3/s]
##set1 ZoneHWTolerance = 0.001                      ! Zone tolerance on hot water control [C]
##set1 ZoneHeatCoilUA  = 400.0                      ! Zone heating coil UA [W/K]

VAVZone[]
```

Objects generated:

CONTROLLED ZONE EQUIP CONFIGURATION

ZONE EQUIPMENT LIST

AIR DISTRIBUTION UNIT

NODE LIST

SINGLE DUCT:VAV:REHEAT

COIL:Water:SimpleHeating

BRANCH

DirectAirZone-Autosize[ ] and DirectAirZone[ ]

Describes the zone equipment for one direct-air zone on a packaged system.

The following parameters are required for both commands:

ZoneName

Zone name

AvailSched

Availability schedule name for this VAV terminal unit.

The following parameters are required only for the non-autosize command:

ZoneSuppAirFlow

Zone supply air flow rate [m3/s] at full flow. See DIRECT AIR for more explanation.

```
##set1 ZoneName        = "RESISTIVE ZONE"                ! Zone name
##set1 AvailSched      = "FanAndCoilAvailSched"    ! System Availability Schedule
##set1 ZoneSuppAirFlow = 0.47                      ! Zone supply air flow rate [m3/s]

DirectAirZone[]
```

Objects generated:

    CONTROLLED ZONE EQUIP CONFIGURATION

    ZONE EQUIPMENT LIST

    NODE LIST

    DIRECT AIR

VAVAirLoop-Autosize[ ] and VAVAirLoop[ ]

Describes the air loop and demand-side branches for a single duct VAV reheat system with outside air economizer option. Autosized version uses COIL:WATER:SIMPLECOOLING only and offers options for plenum return and a main heating coil.

The following parameters are required for both commands:

AirSysName

Air handling system name. This name is used as a prefix for the air handling system object names and node names.

NumberOfZones

Number of zones serve by this air loop. Up to 50 zones may be served by one loop.

Zone1Name, Zone2Name, . . . Zone50Name

Names of zone 1, zone 2, . . . zone 50.

AvailSched

Availability schedule for this air loop. See AIR PRIMARY LOOP for more explanation.

CoolAvailSched

Cooling coil availability schedule. See COIL:WATER:SIMPLECOOLING or COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ColdSupplyTSch

Cooling supply air temperature setpoint control schedule [C]. Sets the setpoint at the air loop exit after the supply fan. Cooling coil setpoint is set based on this to allow for supply fan heat. See SET POINT MANAGER:SCHEDULED and SET POINT MANAGER:MIXED AIR for more explanation.

MinOASched

Minimum Outside Air Schedule Name (" " if no schedule). See CONTROLLER:OUTSIDE AIR for more explanation.

The following parameters are valid only for the autosize command:

ReturnPath

Return air path, PLENUM or DUCTED. Optional parameter, defaults to DUCTED if not set. PLENUM uses a single plenum for return air from all zones served by this air loop.

PlenumZoneName

Zone name of plenum zone. Required if ReturnPath = PLENUM.

OASys

Outside air system flag: YES or NO. If YES, then an outside air mixing box and controller will be included. Optional parameter, defaults to NO.

HeatingCoil

Main heating coil flag: YES or NO. If YES, then a central heating coil and controller will be included. Optional parameter, defaults to NO.

HeatSupplyTSch

Heating coil leaving air temperature setpoint control schedule [C]. See SET POINT MANAGER:SCHEDULED for more explanation. Required only if HeatingCoil = YES.

The following parameters are required only for the non-autosize command:

SysSuppAirFlow

System supply air flow rate [m3/s] at full flow. See AIR PRIMARY LOOP for more explanation.

Parameters for simple cooling coil

ChWCoilType

Cooling coil type: SIMPLE or DETAILED. SIMPLE uses COIL:WATER:SIMPLECOOLING; DETAILED uses COIL:WATER:DETAILEDFLATCOOLING.

ChWCoilMaxChWFlw

Maximum chilled water flow rate through the coil [m3/sec]. See COIL:WATER:SIMPLECOOLING or COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ChWCoilUA

Chilled water coil UA [W/K]. See COIL:WATER:SIMPLECOOLING for more explanation.

ChWCoilLvRH

Chilled water coil leaving relative humidity [fraction, 0 to 1]. See COIL:WATER:SIMPLECOOLING for more explanation.

End Parameters for simple cooling coil

Parameters for detailed cooling coil

ChWCoilType

Cooling coil type: SIMPLE or DETAILED. SIMPLE uses COIL:WATER:SIMPLECOOLING; DETAILED uses COIL:WATER:DETAILEDFLATCOOLING.

ChWCoilMaxChWFlw

Maximum chilled water flow rate through the coil [m3/sec]. See COIL:WATER:SIMPLECOOLING or COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ChWCoilTubeOSA

Tube outside surface area [m2]. See COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ChWCoilTubeISA

Tube inside surface area [m2]. See COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ChWCoilFinSA

Fin surface area [m2]. See COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ChWCoilMinArea

Minimum air flow area [m2]. See COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ChWCoilDepth

Coil depth [m]. See COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ChWCoilHeight

Coil height [m]. See COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ChWCoilFinThick

Fin thickness [m]. See COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ChWCoilTubeID

Tube inside diameter [m]. See COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ChWCoilTubOD

Tube outside diameter [m]. See COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ChWCoilTubeCond

Tube thermal conductivity [W/m-K]. See COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ChWCoilFinCond

Fin thermal conductivity [W/m-K]. See COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ChWCoilFinSpace

Fin spacing [m]. See COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ChWCoilTubeDepth

Tube depth spacing   [m]. See COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ChWCoilNumRow

Number of tube rows. See COIL:WATER:DETAILEDFLATCOOLING for more explanation.

ChWCoilTubPerRow

Number of tubes per row. See COIL:WATER:DETAILEDFLATCOOLING for more explanation.

End Parameters for detailed cooling coil

ChWCtrlOffset

Controller convergence tolerance [C]. See CONTROLLER:SIMPLE for more explanation.

ChWCtrlMaxFlow

Cooling Coil Control Max Actuated Flow [m3/s]. See CONTROLLER:SIMPLE for more explanation.

ChWCtrlMinFlow

Cooling Coil Control Min Actuated Flow [m3/s]. See CONTROLLER:SIMPLE for more explanation.

FanEffic

Fan Total Efficiency. See FAN:SIMPLE:VARIABLEVOLUME for more explanation.

FanPressure

Delta Pressure [Pa]. See FAN:SIMPLE:VARIABLEVOLUME for more explanation.

FanMinVolFlow

Min Vol Flow Rate [m3/s]. See FAN:SIMPLE:VARIABLEVOLUME for more explanation.

FanMtrEffic

Motor efficiency. See FAN:SIMPLE:VARIABLEVOLUME for more explanation.

FanMtrInAir

Motor in air stream fraction. See FAN:SIMPLE:VARIABLEVOLUME for more explanation.

VAVFanCoeff1

VAVFanCoeff2. See FAN:SIMPLE:VARIABLEVOLUME for more explanation.

VAVFanCoeff3

VAVFanCoeff4

VAVFanCoeff5

These parameters are the coefficients of the fan power part load curve.. See FAN:SIMPLE:VARIABLEVOLUME for more explanation.

MinOAFlow

Minimum OA Vol Flow Rate [m3/s]. See CONTROLLER:OUTSIDE AIR for more explanation.

MaxOAFlow

Maximum OA Vol Flow Rate [m3/s]. See CONTROLLER:OUTSIDE AIR for more explanation.

EconoChoice

ECONOMIZER or NO ECONOMIZER. See CONTROLLER:OUTSIDE AIR for more explanation.

RATempLimit

RETURN AIR TEMP LIMIT or NO RETURN AIR TEMP LIMIT. See CONTROLLER:OUTSIDE AIR for more explanation.

RAEnthLimit

RETURN AIR ENTHALPY LIMIT or NO RETURN AIR ENTHALPY LIMIT. See CONTROLLER:OUTSIDE AIR for more explanation.

EconoDXLockout

LOCKOUT or NO LOCKOUT. See CONTROLLER:OUTSIDE AIR for more explanation.

MinOALimit

FIXED MINIMUM or PROPORTIONAL MINIMUM. See CONTROLLER:OUTSIDE AIR for more explanation.

EconoTempLimitHi

Econo upper temperature limit [C] (" " if no limit). See CONTROLLER:OUTSIDE AIR for more explanation.

EconoTempLimitLo

Econo lower temperature limit [C] (" " if no limit). See CONTROLLER:OUTSIDE AIR for more explanation.

EconoEnthLimit

Econo upper enthalpy limit [J/kg] (" " if no limit). See CONTROLLER:OUTSIDE AIR for more explanation.

```
! VAV Air Loop -Autosized
##set1 AirSysName      = "VAV SYS 1"                 ! Air handling system name
##set1 NumberOfZones   = 5                           ! Number of zones
##set1 Zone1Name       = "SPACE1-1"                  ! Name of Zone 1
##set1 Zone2Name       = "SPACE2-1"                  ! Name of Zone 2
##set1 Zone3Name       = "SPACE3-1"                  ! Name of Zone 3
##set1 Zone4Name       = "SPACE4-1"                  ! Name of Zone 4
##set1 Zone5Name       = "SPACE5-1"                  ! Name of Zone 5
##set1 AvailSched      = "FanAvailSched"             ! System Availability Schedule
##set1 HeatAvailSched  = "ReheatCoilAvailSched"      ! Heating Coil Availability Schedule
##set1 CoolAvailSched  = "CoolingCoilAvailSched"     ! Cooling Coil Availability Schedule
##set1 ReturnPath      = PLENUM                      ! PLENUM or DUCTED return
##set1 PlenumZoneName  = "PLENUM-1"                  ! Zone name of plenum zone
##set1 OASys           = "YES"                       ! Outside air system? (YES or NO, YES defaults to
0.00944 m3/s/person, 20cfm/person)
##set1 ColdSupplyTSch  = "Seasonal Reset Supply Air Temp Sch" ! Cooling Coil Control Setpoint Schedule
##set1 MinOASched      = "Min OA Sched"              ! Minimum Outside Air Schedule Name (" " if no
schedule)
##set1 HeatingCoil     = "YES"                       ! Main heating coil?

VAVAirLoop-Autosize[]
```

```
! VAV Air Loop
##set1 AirSysName      = "VAV SYS 1"                ! Air handling system name
##set1 NumberOfZones   = 3                          ! Number of zones
##set1 Zone1Name       = "RESISTIVE ZONE"           ! Name of Zone 1
##set1 Zone2Name       = "EAST ZONE"                ! Name of Zone 2
##set1 Zone3Name       = "NORTH ZONE"               ! Name of Zone 3


##set1 SysSuppAirFlow  = 1.3                         ! System supply air flow rate [m3/s]
##set1 AvailSched      = "FanAndCoilAvailSched"      ! System Availability Schedule

! Cooling Coil Parameters for COIL:Water:DetailedFlatCooling
##set1 ChWCoilType     = "DETAILED"        ! Cooling coil type: SIMPLE or DETAILED
##set1 CoolAvailSched  = "CoolingCoilAvailSched"     ! Cooling coil availability schedule
##set1 ChWCoilMaxChWFlw = 0.0011           ! Max Water Flow Rate of Coil [m3/sec]
##set1 ChWCoilTubeOSA  = 6.23816           ! Tube Outside Surf Area [m2]
##set1 ChWCoilTubeISA  = 6.20007018,       ! Tube Inside Surf Area [m2]
##set1 ChWCoilFinSA    = 101.7158224,      ! Fin Surf Area [m2]
##set1 ChWCoilMinArea  = 0.300606367,      ! Min Air Flow Area [m2]
##set1 ChWCoilDepth    = 0.165097968,      ! Coil Depth [m]
##set1 ChWCoilHeight   = 0.43507152,       ! Coil Height [m]
##set1 ChWCoilFinThick = 0.001499982,      ! Fin Thickness [m]
##set1 ChWCoilTubeID   = 0.014449958,      ! Tube Inside Diameter [m]
##set1 ChWCoilTubOD    = 0.015879775,      ! Tube Outside Diameter [m]
##set1 ChWCoilTubeCond = 0.385764854,      ! Tube Thermal Conductivity [W/m-K]
##set1 ChWCoilFinCond  = 0.203882537,      ! Fin Thermal Conductivity [W/m-K]
##set1 ChWCoilFinSpace = 0.001814292,      ! Fin Spacing [m]
##set1 ChWCoilTubeDepth = 0.02589977,      ! Tube Depth Spacing  [m]
##set1 ChWCoilNumRow   = 6,                ! Number of Tube Rows
##set1 ChWCoilTubPerRow = 16,              ! Number of Tubes per Row

! Cooling Coil Parameters for COIL:Water:SimpleCooling
!##set1 ChWCoilType     = "SIMPLE"          ! Cooling coil type: SIMPLE or DETAILED
!##set1 CoolAvailSched  = "CoolingCoilAvailSched"     ! Cooling coil availability schedule
!##set1 ChWCoilUA       = autosize          ! ChW Coil UA [W/K]
!##set1 ChWCoilMaxChWFlw = autosize         ! ChW Coil Max Water Flow Rate [m3/sec]
!##set1 ChWCoilLvRH     = 0.9               ! ChW Coil Leaving Relative Humidity [fraction, 0 to 1]

! Cooling Coil Controller Parameters for Controller:Simple
##set1 ChWCtrlOffset   = 0.001     ! Controller Convergence Tolerance [C]
##set1 ChWCtrlMaxFlow  = 0.0011    ! Cooling Coil Control Max Actuated Flow [m3/s]
##set1 ChWCtrlMinFlow  = 0.0       ! Cooling Coil Control Min Actuated Flow [m3/s]
##set1 ColdSupplyTSch  = "Seasonal-Reset-Supply-Air-Temp-Sch" ! Cooling Coil Control Setpoint Schedule

! VAV Fan Parameters for FAN:SIMPLE:VariableVolume
##set1 FanEffic        = 0.7               ! Fan Total Efficiency
##set1 FanPressure     = 600.0             ! Delta Pressure [Pa]
##set1 FanMinVolFlow   = 0.20              ! Min Vol Flow Rate  [m3/s]
##set1 FanMtrEffic     = 0.9               ! Motor efficiency
##set1 FanMtrInAir     = 1.0               ! Motor in air stream fraction
##set1 VAVFanCoeff1    = 0.35071223        ! Fan Coeff 1
##set1 VAVFanCoeff2    = 0.30850535,       ! Fan Coeff 2
##set1 VAVFanCoeff3    =-0.54137364,       ! Fan Coeff 3
##set1 VAVFanCoeff4    = 0.87198823,       ! Fan Coeff 4
##set1 VAVFanCoeff5    = 0.000,            ! Fan Coeff 5

! Outside Air Parameters
##set1 MinOAFlow       =  0.4333                    ! Minimum OA Vol Flow Rate [m3/s]
##set1 MaxOAFlow       =  1.3                       ! Maximum OA Vol Flow Rate [m3/s]
##set1 EconoChoice     = "ECONOMIZER"               ! ECONOMIZER or NO ECONOMIZER
##set1 RATempLimit     = "NO RETURN AIR TEMP LIMIT"     ! RETURN AIR TEMP LIMIT or NO RETURN AIR TEMP
LIMIT
##set1 RAEnthLimit     = "NO RETURN AIR ENTHALPY LIMIT" ! RETURN AIR ENTHALPY LIMIT or NO RETURN AIR
ENTHALPY LIMIT
##set1 EconoDXLockout  = "NO LOCKOUT"               ! LOCKOUT or NO LOCKOUT
##set1 MinOALimit      = "PROPORTIONAL MINIMUM"     ! FIXED MINIMUM or PROPORTIONAL MINIMUM
##set1 EconoTempLimitHi = 19.0                      ! Econo upper temperature limit [C] (" " if no limit)
##set1 EconoTempLimitLo =  4.0                      ! Econo lower temperature limit [C] (" " if no limit)
##set1 EconoEnthLimit  = " "                        ! Econo upper enthalpy limit [J/kg] (" " if no limit)
##set1 MinOASched      = " "                 ! Minimum Outside Air Schedule Name (" " if no schedule)

VAVAirLoop[]
```

Objects generated:

AIR PRIMARY LOOP

CONTROLLER LIST

BRANCH LIST

BRANCH

ZONE SUPPLY AIR PATH

ZONE RETURN AIR PATH

ZONE SPLITTER

ZONE MIXER

CONTROLLER:SIMPLE

SYSTEM AVAILABILITY MANAGER LIST

SYSTEM AVAILABILITY MANAGER:SCHEDULED

SET POINT MANAGER:SCHEDULED

NODE LIST

COIL:WATER:DETAILEDFLATCOOLING

FAN:SIMPLE:VARIABLEVOLUME

OUTSIDE AIR INLET NODE LIST

OUTSIDE AIR SYSTEM

AIR LOOP EQUIPMENT LIST

OUTSIDE AIR MIXER

CONTROLLER:OUTSIDE AIR

UnitaryAirLoop-Autosize[ ] and UnitaryAirLoop[ ]

Describes the air loop for a unitary packaged system with a furnace with optional DX cooling and optional outside air system.

The following parameters are required for both commands:

AirSysName

Air handling system name. This name is used as a prefix for the air handling system object names and node names.

NumberOfZones

Number of zones serve by this air loop. Up to 50 zones may be served by one loop.

Zone1Name, Zone2Name, . . . Zone50Name

Names of zone 1, zone 2, . . . zone 50.

AvailSched

Availability schedule for this air loop. See AIR PRIMARY LOOP for more explanation.

SystemType

Type of unitary system: FURNACE-HEATONLY, FURNACE-HEATCOOL, UNITARY-HEATONLY, or UNITARY-HEATCOOL.   See FURNACE:BLOWTHRU:HEATONLY, FURNACE:BLOWTHRU:HEATCOOL, UNITARYSYSTEM:BLOWTHRU:HEATONLY, or UNITARYSYSTEM:BLOWTHRU:HEATCOOL, respectively, for more explanation.

FanMode

Supply fan mode, CONTINUOUS or CYCLING. Used to set both the furnace or unitary system Operating Mode field and the DX coil Supply Air Fan Operation Mode field. See the selected furnace or unitary system type, and COIL:DX:CoolingBypassFactorEmpirical for more explanation.

ControlZoneName

The zone name of the controlling zone or thermostat location for the furnace or unitary system. See the selected furnace or unitary system type for more explanation.

HeatingCoilType

The type of heating coil: GAS or ELECTRIC. Selects the COIL:GAS:HEATING or COIL:ELECTRIC:HEATING type, respectively.

OASys

Outside air system flag: YES or NO. If YES, then an outside air mixing box and controller will be included.

The following parameters are required only for the non-autosize command:

SysSuppAirFlow

System supply air flow rate [m3/s] at rated flow. See the selected furnace or unitary system type for more explanation.

ControlZoneFrac

Fraction of the total or design volume flow that goes through the controlling zone. See the selected furnace or unitary system type for more explanation.

HeatingCapacity

Furnace heating capacity [W]. See the selected furnace or unitary system type for more explanation.

MaxSupplyTemp

See the selected furnace or unitary system type for more explanation.

GasBurnerEffic

Gas burner efficiency (decimal, not percent). See COIL:Gas:Heating for more explanation.

GasBurnerElec

Parasitic electric load associated with the gas coil operation [W]. See COIL:Gas:Heating for more explanation.

GasBurnerPilot

Parasitic gas load associated with the gas coil's operation [W], such as a standing pilot light. See COIL:Gas:Heating for more explanation.

PLF-FPLR-Curve

Part Load Fraction Correlation (function of part load ratio). Enter a curve object name or "DEFAULT" to use a default curve. See COIL:Gas:Heating for more explanation.

The following parameters are required only if cooling is selected:

CoolingCapacity

Rated Total Cooling Capacity (gross) [W]. See COIL:DX:CoolingBypassFactorEmpirical for more explanation.

RatedSHR

Rated sensible heat ratio. See COIL:DX:CoolingBypassFactorEmpirical for more explanation.

RatedCOP

Rated COP. See COIL:DX:CoolingBypassFactorEmpirical for more explanation.

DX-Cap-FT-Curve

Total cooling capacity modifier curve (function of temperature). Enter a curve object name or "DEFAULT" to use a default curve. See COIL:DX:CoolingBypassFactorEmpirical for more explanation.

DX-Cap-FF-Curve

Total cooling capacity modifier curve (function of flow fraction). Enter a curve object name or "DEFAULT" to use a default curve. See COIL:DX:CoolingBypassFactorEmpirical for more explanation.

DX-EIR-FT-Curve

Energy input ratio modifier curve (function of temperature). Enter a curve object name or "DEFAULT" to use a default curve. See COIL:DX:CoolingBypassFactorEmpirical for more explanation.

DX-EIR-FF-Curve

Energy input ratio modifier curve (function of flow fraction). Enter a curve object name or "DEFAULT" to use a default curve. See COIL:DX:CoolingBypassFactorEmpirical for more explanation.

DX-PLF-Curve

Part load fraction correlation (function of part load ratio). Enter a curve object name or "DEFAULT" to use a default curve. See COIL:DX:CoolingBypassFactorEmpirical for more explanation.

End cooling coil parameters.

The following parameters are required only if and outside air system is selected:

MinOAFlow

Minimum OA Vol Flow Rate [m3/s]. See CONTROLLER:OUTSIDE AIR for more explanation.

MaxOAFlow

Maximum OA Vol Flow Rate [m3/s]. See CONTROLLER:OUTSIDE AIR for more explanation.

EconoChoice

ECONOMIZER or NO ECONOMIZER. See CONTROLLER:OUTSIDE AIR for more explanation.

RATempLimit

RETURN AIR TEMP LIMIT or NO RETURN AIR TEMP LIMIT. See CONTROLLER:OUTSIDE AIR for more explanation.

RAEnthLimit

RETURN AIR ENTHALPY LIMIT or NO RETURN AIR ENTHALPY LIMIT. See CONTROLLER:OUTSIDE AIR for more explanation.

EconoDXLockout

LOCKOUT or NO LOCKOUT. See CONTROLLER:OUTSIDE AIR for more explanation.

MinOALimit

FIXED MINIMUM or PROPORTIONAL MINIMUM. See CONTROLLER:OUTSIDE AIR for more explanation.

EconoTempLimitHi

Econo upper temperature limit [C] (" " if no limit). See CONTROLLER:OUTSIDE AIR for more explanation.

EconoTempLimitLo

Econo lower temperature limit [C] (" " if no limit). See CONTROLLER:OUTSIDE AIR for more explanation.

EconoEnthLimit

Econo upper enthalpy limit [J/kg] (" " if no limit). See CONTROLLER:OUTSIDE AIR for more explanation.

MinOASched

Minimum Outside Air Schedule Name (" " if no schedule). See CONTROLLER:OUTSIDE AIR for more explanation.

End outside air system parameters.

```
! DX Air Loop - Autosized
##set1 AirSysName        = "AHU 1"                 ! Air handling system name
##set1 AvailSched        = "FanAndCoilAvailSched"  ! System Availability Schedule
##set1 NumberOfZones     = 1                       ! Number of zones
##set1 Zone1Name         = "ZONE ONE"             ! Name of Zone 1

! Furnace Parameters
##set1 SystemType        = "FURNACE-HEATCOOL"      ! System type (FURNACE-HEATONLY, FURNACE-HEATCOOL,
UNITARY-HEATONLY, or UNITARY-HEATCOOL)
##set1 FanMode           = Cycling                 ! Fan Operating Mode: Cycling or Continuous
##set1 ControlZoneName   = "ZONE ONE"             ! Controlling zone or thermostat location
##set1 HeatingCoilType   = "GAS"                   ! Heating coil type - Gas or Electric
##set1 OASys             = "NO"                    ! Outside air system? (YES or NO, YES defaults to
0.00944 m3/s/person, 20cfm/person)

UnitaryAirLoop-Autosize[]
```

```
! DX Air Loop
! (See comments in DXAirLoop macro definition for variable definitions)
##set1 AirSysName       = "Furnace SYS 1"            ! Air handling system name
##set1 NumberOfZones    = 3                          ! Number of zones
##set1 Zone1Name        = "RESISTIVE ZONE"           ! Name of Zone 1
##set1 Zone2Name        = "EAST ZONE"                ! Name of Zone 2
##set1 Zone3Name        = "NORTH ZONE"               ! Name of Zone 3


##set1 SysSuppAirFlow   = 1.3                        ! System supply air flow rate [m3/s]
##set1 AvailSched       = "FanAndCoilAvailSched"     ! System Availability Schedule

! Furnace Parameters for FURNACE:BLOWTHRU:HEATCOOL
##set1 SystemType       = "FURNACE-HEATCOOL"         ! System type (FURNACE-HEATONLY, FURNACE-HEATCOOL,
UNITARY-HEATONLY, or UNITARY-HEATCOOL)
##set1 FanMode          = Cycling                    ! Fan Operating Mode: Cycling or Continuous
##set1 HeatingCapacity  = 25000                      ! Furnace heating capacity [W]
##set1 MaxSupplyTemp    = 80                         ! Maximum supply air temperature from furnace heater
{C}
##set1 ControlZoneName  = "EAST ZONE"                ! Controlling zone or thermostat location
##set1 ControlZoneFrac  = 0.276923                   ! Fraction of the total or design volume flow that
goes through the controlling zone
##set1 HeatingCoilType  = "GAS"                      ! Heating coil type - Gas or Electric
##set1 GasBurnerEffic   = 0.8                        ! Gas Burner Efficiency of the Coil [fraction]
##set1 GasBurnerElec    = 0.0                        ! Gas Burner Parasitic Electric Load [W]
##set1 PLF-FPLR-Curve   = "None"                     ! Gas Burner Part load fraction correlation
(function of part load ratio)
##set1 CoolingCapacity  = 25000                      ! DX Coil cooling capacity [W]
##set1 RatedSHR         = 0.75                       ! rated SHR
##set1 RatedCOP         = 3.0                        ! rated COP
##set1 DX-Cap-FT-Curve  = "Default"                  ! total cooling capacity modifier curve (function of
temperature)
##set1 DX-Cap-FF-Curve  = "Default"                  ! total cooling capacity modifier curve (function of
flow fraction)
##set1 DX-EIR-FT-Curve  = "Default"                  ! energy input ratio modifier curve (function of
temperature)
##set1 DX-EIR-FF-Curve  = "Default"                  ! energy input ratio modifier curve (function of
flow fraction)
##set1 DX-PLF-Curve     = "Default"                  ! part load fraction correlation (function of part
load ratio)

! Fan Parameters for FAN:SIMPLE:ONOFF
##set1 FanEffic         = 0.7            ! Fan Total Efficiency
##set1 FanPressure      = 600.0          ! Delta Pressure [Pa]
##set1 FanMinVolFlow    = 0.20           ! Min Vol Flow Rate  [m3/s]
##set1 FanMtrEffic      = 0.9            ! Motor efficiency
##set1 FanMtrInAir      = 1.0            ! Motor in air stream fraction

! Outside Air Parameters
##set1 MaxOAFlow        =  0.0                          ! Maximum OA Vol Flow Rate [m3/s]
! If no outside air, the following parameters may be omitted:
! ##set1 MinOAFlow       =  0.4333                       ! Minimum OA Vol Flow Rate [m3/s]
! ##set1 EconoChoice     = "ECONOMIZER"                  ! ECONOMIZER or NO ECONOMIZER
! ##set1 RATempLimit     = "NO RETURN AIR TEMP LIMIT"    ! RETURN AIR TEMP LIMIT or NO RETURN AIR TEMP
LIMIT
! ##set1 RAEnthLimit     = "NO RETURN AIR ENTHALPY LIMIT" ! RETURN AIR ENTHALPY LIMIT or NO RETURN AIR
ENTHALPY LIMIT
! ##set1 EconoDXLockout  = "NO LOCKOUT"                  ! LOCKOUT or NO LOCKOUT
! ##set1 MinOALimit      = "PROPORTIONAL MINIMUM"        ! FIXED MINIMUM or PROPORTIONAL MINIMUM
! ##set1 EconoTempLimitHi = 19.0                         ! Econo upper temperature limit [C] (" " if no
limit)
! ##set1 EconoTempLimitLo =  4.0                         ! Econo lower temperature limit [C] (" " if no
limit)
! ##set1 EconoEnthLimit   = " "                          ! Econo upper enthalpy limit [J/kg] (" " if no
limit)
! ##set1 MinOASched       = " "                          ! Minimum Outside Air Schedule Name (" " if no
schedule)

UnitaryAirLoop[]
```

Objects generated:

AIR PRIMARY LOOP

BRANCH LIST

BRANCH

ZONE SUPPLY AIR PATH

ZONE RETURN AIR PATH

ZONE SPLITTER

ZONE MIXER

SYSTEM AVAILABILITY MANAGER LIST

SYSTEM AVAILABILITY MANAGER:SCHEDULED

SET POINT MANAGER:SCHEDULED

Option – select one

    FURNACE:BLOWTHRU:HEATONLY

    FURNACE:BLOWTHRU:HEATCOOL

    UNITARYSYSTEM:BLOWTHRU:HEATONLY

    UNITARYSYSTEM:BLOWTHRU:HEATCOOL

Option – select one

    COIL:ELECTRIC:HEATING

    COIL:GAS:HEATING

CURVE:BIQUADRATIC – *if default selected*

CURVE:QUADRATIC – *if default selected*

COIL:DX:BF-EMPIRICAL – *if cooling selected*

FAN:SIMPLE:ONOFF

Option – if outside air system selected

    OUTSIDE AIR INLET NODE LIST

    OUTSIDE AIR SYSTEM

    CONTROLLER LIST

    AIR LOOP EQUIPMENT LIST

    OUTSIDE AIR MIXER

    CONTROLLER:OUTSIDE AIR

    SET POINT MANAGER:SINGLE ZONE REHEAT

    SET POINT MANAGER:MIXED AIR

FanCoilLoops-Autosize[ ] *(Not implemented yet)* **and FanCoilLoops[ ]**

Describes the demand-side chilled water and hot water loops for a four pipe fan coil system..

The following parameters are required for both commands (the two commands are identical):

DemandSysName

Demand side system name. This name is used to link supply-side loops to these demand-side loops. This name is used as a prefix for the demand-side object names and node names.

NumberOfZones

Number of zones served by these demand-side loops. Up to 50 zones may be served by one loop.

Zone1Name, Zone2Name, . . . Zone50Name

Names of zone 1, zone 2, . . . zone 50.

```
FanCoilLoops[]! Fan Coil Loops
! (See comments in FanCoilLoops macro definition for variable definitions)
##set1 DemandSysName    = "FAN COILS"        ! Demand side system name
##set1 NumberOfZones    = 3                  ! Number of zones
##set1 Zone1Name        = "RESISTIVE ZONE"   ! Name of zone 1
##set1 Zone2Name        = "EAST ZONE"        ! Name of zone 2
##set1 Zone3Name        = "NORTH ZONE"       ! Name of zone 3

FanCoilLoops[]
```

Objects generated:

> BRANCH LIST
>
> CONNECTOR LIST
>
> SPLITTER
>
> MIXER
>
> PIPE

ChilledWaterDemand-Autosize[ ] and ChilledWaterDemand[ ]

Describes a demand-side chilled water loop serving cooling coils serving zones or air loops.

The following parameters are required for both commands (the two commands are identical):

ChWDemandSysName

Demand side system name. This name is used to link supply-side loops to these demand-side loops. This name is used as a prefix for the demand-side object names and node names.

NumberOfChWCoils

Number of chilled water coils served by these demand-side loops. Up to 50 coils may be served by one loop.

ChWCoil1Name, ChWCoil2Name, . . . ChWCoil50Name

Names of chilled water coil 1, coil 2, . . . coil 50.

```
! Chilled Water Demand Side
##set1 ChWDemandSysName = "Chilled Water Loop 1"   ! Chiller water demand side system name
##set1 NumberOfChWCoils = 1                        ! Number of chilled water coils on loop
##set1 ChWCoil1Name     = "VAV SYS 1"              ! Name of Zone or Air Loop for ChW Coil 1

ChilledWaterDemand[]
```

Objects generated:

BRANCH LIST

CONNECTOR LIST

SPLITTER

MIXER

PIPE

HotWaterDemand-Autosize[ ] and HotWaterDemand[ ]

Describes a demand-side hot water loop serving heating coils serving zones or air loops.

The following parameters are required for both commands (the two commands are identical):

HWDemandSysName

Demand side system name. This name is used to link supply-side loops to these demand-side loops. This name is used as a prefix for the demand-side object names and node names.

NumberOfHWCoils

Number of hot water coils served by these demand-side loops. Up to 50 coils may be served by one loop.

HWCoil1Name, HWCoil2Name, . . . HWCoil50Name

Names of hot water coil 1, coil 2, . . . coil 50.

```
! Hot Water Demand Side
##set1 HWDemandSysName  = "Hot Water Loop 1"        ! Hot water demand side system name
##set1 NumberOfHWCoils  = 3                         ! Number of hot water coils on loop
##set1 HWCoil1Name      = "RESISTIVE ZONE"          ! Name of Zone or Air Loop for HW Coil 1
##set1 HWCoil2Name      = "EAST ZONE"               ! Name of Zone or Air Loop for HW Coil 2
##set1 HWCoil3Name      = "NORTH ZONE"              ! Name of Zone or Air Loop for HW Coil 3

HotWaterDemand[]
```

Objects generated:

BRANCH LIST

CONNECTOR LIST

SPLITTER

MIXER

PIPE

PurchasedSupplyWithBypass-Autosize[ ] *(Not implemented yet)* and PurchasedSupplyWithBypass[ ]

Describes the supply side equipment and branches for a purchased hot water and chilled water plant with bypass branches.

The following parameters are required for both commands:

SupplyPlantName

Name of this supply side loop. This name is used as a prefix for the supply-side object names and node names.

ChWDemandSysName

Name of the chilled water demand-side loop served by this supply-side loop.

HWDemandSysName

Name of the hot water demand-side loop served by this supply-side loop.

PurchChWSched

Purchased ChW availability schedule. See PLANT OPERATION SCHEMES for more explanation.

PurchHWSched

Purchased HW availability schedule. See PLANT OPERATION SCHEMES for more explanation.

The following parameters are required only for the non-autosize command:

PurchChWCap

Purchased ChW capacity [W]. See PURCHASED:CHILLED WATER for more explanation.

PurchHWCap

Purchased HW capacity [W] . See PURCHASED:HOT WATER for more explanation.

All parameters in the Chilled Water Loop Parameter Group (see below)

All parameters in the Hot Water Loop Parameter Group (see below)

All parameters in the Chilled Water Pump Parameter Group (see below)

All parameters in the Hot Water Pump Parameter Group (see below)

```
! Purchased Heating and Cooling Supply
! (See comments in PurchasedSupply macro definition for variable definitions)
##set1 ChWDemandSysName = "FAN COILS"  ! ChW demand-side loop served by this supply-side loop
##set1 HWDemandSysName  = "FAN COILS"  ! HW  demand-side loop served by this supply-side loop
##set1 SupplyPlantName  = "PURCHASED PLANT"  ! Name of this supply side loop

##set1 ChWLoopMaxFlow   = 0.004              ! Max ChW flow (total to all zones) [m3/s]
##set1 ChWLoopMinFlow   = 0                  ! Min ChW flow (total to all zones) [m3/s]
##set1 ChWLoopTempSch   = "None"             ! Chilled water setpoint schedule [C]
##set1 ChWLoopSetPoint  = 6.67               ! Chilled water setpoint [C] if schedule=None
##set1 ChWLoopMaxTemp   = 50                 ! Max ChW temperature [C]
##set1 ChWLoopMinTemp   = 1                  ! Min ChW temperature [C]
##set1 ChWLoopVolume    = autosize           ! ChW loop volume [m3]

##set1 HWLoopMaxFlow    = 0.002              ! Max HW flow (total to all zones) [m3/s]
##set1 HWLoopMinFlow    = 0                  ! Min HW flow (total to all zones) [m3/s]
##set1 HWLoopTempSch    = "None"             ! Hot water setpoint schedule [C]
##set1 HWLoopSetPoint   = 60                 ! Hot water setpoint [C] if schedule=None
##set1 HWLoopMaxTemp    = 100                ! Max HW temperature [C]
##set1 HWLoopMinTemp    = 10                 ! Min HW temperature [C]
##set1 HWLoopVolume     = autosize           ! HW loop volume [m3]

##set1 PurchChWCap      = 1000000            ! Purchased ChW capacity [W]
##set1 PurchChWSched    = "ON"               ! Purchased ChW availability schedule
##set1 PurchHWCap       = 1000000            ! Purchased HW capacity [W]
##set1 PurchHWSched     = "ON"               ! Purchased HW availability schedule

##set1 ChWPmpType       = "Variable"     ! ChW Pump Type [Variable or Constant]
##set1 ChWPmpHead       = 300000         ! ChW Pump Rated Pump Head [Pa]
##set1 ChWPmpPower      = 1800           ! ChW Pump Rated Power Consumption [W]
##set1 ChWPmpMtrEff     = 0.87           ! ChW Pump Motor Efficiency
##set1 ChWPmpMtrToFluid = 0.0            ! ChW Pump Frac Motor Inefficiencies to Fluid
##set1 ChWPmpPtLdCoeff1 = 1.0            ! ChW Pump Coefficient1 Part Load Perf. Curve
##set1 ChWPmpPtLdCoeff2 = 0.0            ! ChW Pump Coefficient2 Part Load Perf. Curve
##set1 ChWPmpPtLdCoeff3 = 0.0            ! ChW Pump Coefficient3 Part Load Perf. Curve
##set1 ChWPmpPtLdCoeff4 = 0.0            ! ChW Pump Coefficient4 Part Load Perf. Curve
##set1 ChWPmpCtrl       = "INTERMITTENT" ! ChW pump control type: INTERMITTENT or CONTINUOUS

##set1 HWPmpType        = "Variable"     ! HW Pump Type [Variable or Constant]
##set1 HWPmpHead        = 300000         ! HW Pump Rated Pump Head [Pa]
##set1 HWPmpPower       = 900            ! HW Pump Rated Power Consumption [W]
##set1 HWPmpMtrEff      = 0.87           ! HW Pump Motor Efficiency
##set1 HWPmpMtrToFluid  = 0.0            ! HW Pump Frac Motor Inefficiencies to Fluid
##set1 HWPmpPtLdCoeff1  = 1.0            ! HW Pump Coefficient1 Part Load Perf. Curve
##set1 HWPmpPtLdCoeff2  = 0.0            ! HW Pump Coefficient2 Part Load Perf. Curve
##set1 HWPmpPtLdCoeff3  = 0.0            ! HW Pump Coefficient3 Part Load Perf. Curve
##set1 HWPmpPtLdCoeff4  = 0.0            ! HW Pump Coefficient4 Part Load Perf. Curve
##set1 HWPmpCtrl        = "INTERMITTENT" ! HW pump control type: INTERMITTENT or CONTINUOUS

PurchasedSupplyWithBypass[]
```

Objects generated:

    PLANT LOOP

    BRANCH LIST

    CONNECTOR LIST

    SPLITTER

    MIXER

    BRANCH

    PIPE

    Option – select one

PUMP:VARIABLE SPEED

PUMP:CONSTANT SPEED

PLANT OPERATION SCHEMES

COOLING LOAD RANGE BASED OPERATION

HEATING LOAD RANGE BASED OPERATION

LOAD RANGE EQUIPMENT LIST

PURCHASED:CHILLED WATER

PURCHASED:HOT WATER

BoilerSupply1-Autosize[ ] *(Not implemented yet)* and BoilerSupply1[ ]

BoilerSupply1WithBypass-Autosize[ ] and BoilerSupply1WithBypass[ ]

Describes the supply side loop, equipment, and branches for a single boiler plant or purchased hot water plant with or without bypass.

The following parameters are required for both autosize and non-autosize commands:

HWLoopName

Name of this supply side loop. This name is used as a prefix for the supply-side object names and node names.

HWDemandSysName

Name of the hot water demand-side loop served by this supply-side loop.

HWLoopAvailSch

Boiler loop availability schedule. See PLANT OPERATION SCHEMES for more explanation.

HWLoopTempSch

Hot water setpoint schedule [C]. If fixed setpoint, then set this to "None". See PLANT LOOP for more explanation. For the autosized command, if omitted or set to "None", defaults to constant setpoint of 82C.

BoilerType

Type of boiler object: BOILER-SIMPLE or PURCHASED-HOT-WATER. Uses BOILER:SIMPLE or PURCHASED:HOT WATER, respectively.

BoilerFuel

Boiler fuel type (required only if BoilerType=BOILER:SIMPLE). The fuel type can be Electricity, NaturalGas, PropaneGas, FuelOil#1, FuelOil#2, Coal, Diesel, or Gasoline. For the autosized command, if omitted, defaults to NaturalGas. See BOILER:SIMPLE for more explanation.

BoilerFlowMode

Boiler Flow Mode: ConstantFlow or VariableFlow (required only if BoilerType=BOILER:SIMPLE). For the autosized command, if omitted, defaults to ConstantFlow. See BOILER:SIMPLE for more explanation.

HWPmpType

Hot water pump type, VARIABLE or CONSTANT speed. For autosized command, if omitted, defaults to VARIABLE.

HWPmpCtrl

Hot water pump control type: INTERMITTENT or CONTINUOUS. See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation. For autosized command, if omitted, defaults to INTERMITTENT.

The following parameters are required only for the non-autosize command:

All parameters in the Hot Water Loop Parameter Group (see below)

All parameters in the Hot Water Pump Parameter Group (see below)

All parameters in the Boiler Parameter Group (see below)

```
! Single Boiler Supply - Autosized
##set1 HWLoopName      = "Boiler Plant"          ! Supply side plant name
##set1 HWDemandSysName  = "HW Demand 1"           ! Hot water demand side system name
##set1 HWLoopAvailSch  = "PlantOnSched"          ! Boiler availability schedule
##set1 HWLoopTempSch   = "HW-Loop-Temp-Schedule" ! Hot water setpoint schedule [C]
##set1 BoilerType      = "BOILER-SIMPLE"         ! Boiler Object Type (all dashes)
##set1 BoilerFuel      = "NaturalGas"            ! Boiler fuel type
##set1 BoilerFlowMode  = "VariableFlow"          ! Boiler Flow Mode: ConstantFlow or VariableFlow
##set1 HWPmpType       = "Variable"              ! HW Pump Type [Variable or Constant]
##set1 HWPmpCtrl       = "INTERMITTENT"          ! HW pump control type: INTERMITTENT or CONTINUOUS

BoilerSupply1WithBypass-Autosize[]
```

```
! Single Boiler Supply
##set1 HWDemandSysName  = "Hot Water Loop 1"        ! Hot water demand side system name
##set1 HWLoopName       = "Boiler Plant"            ! Supply side plant name
##set1 HWLoopAvailSch   = "ON"                      ! Boiler availability schedule
##set1 HWLoopTempSch    = "HW-Loop-Temp-Schedule"   ! Hot water setpoint schedule [C]
##set1 HWLoopSetPoint   =                           ! Hot water setpoint [C] if schedule=None
##set1 HWLoopMaxTemp    = 100                       ! Max hot water temperature [C]
##set1 HWLoopMinTemp    = 1                         ! Min hot water temperature [C]
##set1 HWLoopMaxFlow    = #[3 * 0.0013]             ! Max HW flow (total to all zones) [m3/s]
##set1 HWLoopMinFlow    = 0                         ! Min HW flow (total to all zones) [m3/s]
##set1 HWLoopVolume     = autosize                  ! HW loop volume [m3]

! Boiler Parameters for PURCHASED:HOT WATER
! ##set1 BoilerType      = "PURCHASED-HOT-WATER"    ! Boiler Object Type (all dashes)
! ##set1 BoilerCap       = 1000000                  ! Boiler capacity [W]

! Boiler Parameters for BOILER:SIMPLE
##set1 BoilerType      = "BOILER-SIMPLE"            ! Boiler Object Type (all dashes)
##set1 BoilerCap       = 30000                      ! Boiler capacity [W]
##set1 BoilerFuel      = GAS                        ! Boiler fuel
##set1 BoilerEffic     = 0.8                        ! Boiler Theoretical Efficiency
##set1 BoilerMinPtLd   = 0.010                      ! Boiler Minimum Part Load Ratio
##set1 BoilerMaxPtLd   = 1.00                       ! Boiler Maximum Part Load Ratio
##set1 BoilerOptPtLd   = 1.00                       ! Boiler Optimum Part Load Ratio
##set1 BoilerPtLdCoeff1 = 1.0                       ! Boiler Coefficient1 Part Load Perf. Curve
##set1 BoilerPtLdCoeff2 = 0.0                       ! Boiler Coefficient2 Part Load Perf. Curve
##set1 BoilerPtLdCoeff3 = 0.0                       ! Boiler Coefficient3 Part Load Perf. Curve
##set1 BoilerFlowMode  = ConstantFlow               ! Boiler Flow Mode: ConstantFlow or VariableFlow


! Hot Water Pump Parameters for PUMP:VARIABLE SPEED
##set1 HWPmpType       = "Variable"     ! HW Pump Type [Variable or Constant]
##set1 HWPmpHead       = 300000                     ! HW Pump Rated Pump Head [Pa]
##set1 HWPmpPower      = 2273                       ! HW Pump Rated Power Consumption [W]
##set1 HWPmpMtrEff     = 0.87                       ! HW Pump Motor Efficiency
##set1 HWPmpMtrToFluid = 0.0                        ! HW Pump Frac Motor Inefficiencies to Fluid
##set1 HWPmpPtLdCoeff1 = 1.0                        ! HW Pump Coefficient1 Part Load Perf. Curve
##set1 HWPmpPtLdCoeff2 = 0.0                        ! HW Pump Coefficient2 Part Load Perf. Curve
##set1 HWPmpPtLdCoeff3 = 0.0                        ! HW Pump Coefficient3 Part Load Perf. Curve
##set1 HWPmpPtLdCoeff4 = 0.0                        ! HW Pump Coefficient4 Part Load Perf. Curve
##set1 HWPmpCtrl       = "INTERMITTENT"             ! HW pump control type: INTERMITTENT or CONTINUOUS

! BoilerSupply1[]
BoilerSupply1WithBypass[]
```

Objects generated:

PLANT LOOP

BRANCH LIST

CONNECTOR LIST

SPLITTER

MIXER

BRANCH

PIPE

PUMP:VARIABLE SPEED

PLANT OPERATION SCHEMES

HEATING LOAD RANGE BASED OPERATION

LOAD RANGE EQUIPMENT LIST

PURCHASED:HOT WATER

Option – select one

BOILER:SIMPLE

(additional options will be made available)

ChillerSupply1-Autosize[ ] *(Not implemented yet)* and ChillerSupply1[ ]

ChillerSupply1WithBypass-Autosize[ ] and ChillerSupply1WithBypass[ ]

Describes the supply side equipment and branches for a single chiller plant or purchased chilled water plant with or without bypass.

The following parameters are required for both autosize and non-autosize commands:

ChWLoopName

Name of this supply side loop. This name is used as a prefix for the supply-side object names and node names.

ChWDemandSysName

Name of the chilled water demand-side loop served by this supply-side loop.

ChWLoopAvailSch

Chiller loop availability schedule. See PLANT OPERATION SCHEMES for more explanation.

ChWLoopTempSch

Chilled water setpoint schedule name [C]. If fixed setpoint, then set this to "None". See PLANT LOOP for more explanation. For the autosized command, if omitted or set to "None", defaults to constant setpoint of 7.22 C.

ChillerType

Type of chiller object: CHILLER-ELECTRIC (autosized only), CHILLER-CONST-COP (non-autosized only) or PURCHASED-CHILLED-WATER.   Uses CHILLER:ELECTRIC, CHILLER:CONST COP or PURCHASED:CHILLED WATER, respectively.

ChillerCOP

Chiller COP. See CHILLER:ELECTRIC or CHILLER:CONST COP for more explanation. For autosized command, if omitted, defaults to 3.2.

ChillerCondType

Chiller condenser type: WATER COOLED, AIR COOLED, or EVAP COOLED.   See CHILLER:ELECTRIC or CHILLER:CONST COP for more explanation.   For autosized command, if omitted, defaults to WATER-COOLED.

ChillerFlowMode

Chiller Flow Mode: ConstantFlow or VariableFlow.   See CHILLER:ELECTRIC or CHILLER:CONST COP for more explanation. Not required if ChillerType – PURCHASED-CHILLED-WATER. For autosized command, if omitted, defaults to ConstantFlow.

ChWPmpType

Chilled water pump type, VARIABLE or CONSTANT speed. For autosized command, if omitted, defaults to VARIABLE.

ChWPmpCtrl

Chilled water pump control type: INTERMITTENT or CONTINUOUS. See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation. For autosized command, if omitted, defaults to INTERMITTENT.

The following parameters are required only for the non-autosize command:

All parameters in the Chilled Water Loop Parameter Group (see below)

All parameters in the Chilled Water Pump Parameter Group (see below)

All parameters in the Chiller Parameter Group (see below)

```
! Single Chiller Supply - Autosized
##set1 ChWLoopName      = "Chiller Plant"          ! Supply side plant name
##set1 ChWDemandSysName = "CHW Demand 1"           ! Chilled water demand side system
##set1 ChWLoopAvailSch  = "PlantOnSched"           ! Chiller availability schedule
##set1 ChWLoopTempSch   = "CW-Loop-Temp-Schedule"  ! Chilled water setpoint schedule [C]
##set1 ChillerType      = "CHILLER-ELECTRIC"       ! Chiller Object Type (PURCHASED-CHILLED-WATER or
                                                   !    CHILLER-ELECTRIC)
##set1 ChillerCOP       = 3.2                       ! Chiller COP (optional, defaults to 3.2)
##set1 ChillerFlowMode  = "VariableFlow"           ! Chiller Flow Mode: ConstantFlow or VariableFlow
##set1 ChillerCondType  = "WATER-COOLED"           ! Chiller condenser type: WATER-COOLED, AIR-COOLED, or
                                                   !    EVAP-COOLED
##set1 ChWPmpType       = "Variable"               ! ChW Pump Type [Variable or Constant]
##set1 ChWPmpCtrl       = "INTERMITTENT"           ! ChW pump control type: INTERMITTENT or CONTINUOUS
```

```
! Single Chiller Supply
! Chiller Parameters for PURCHASED:CHILLED WATER
! ##set1 ChillerType      = "PURCHASED-CHILLED-WATER"! Chiller Object Type (all dashes)
! ##set1 ChillerCap       = 1000000                  ! Chiller capacity [W]

! Chiller Parameters for CHILLER:CONST COP
##set1 ChillerType        = "CHILLER-CONST-COP"      ! Chiller Object Type (all dashes)
##set1 ChillerCap         = 30000                    ! Chiller capacity [W]
##set1 ChillerCOP         = 5.85                     ! Chiller COP
! 4.312E-8 m3/s per W is equivalent to 2.4 gpm per ton
##set1 ChillerEvWFlow     = #[ChillerCap[] * 0.00000004312] ! Chiller evaporator vol flow rate [m3/s]
! 5.39E-8 m3/s per W is equivalent to 3 gpm per ton
##set1 ChillerCdWFlow     = #[ChillerCap[] * 0.0000000539] ! Chiller condenser vol flow rate [m3/s]
##set1 ChillerCondType    = "WATER COOLED"           ! Chiller condenser type: WATER COOLED, AIR COOLED, or
EVAP COOLED
##set1 ChillerFlowMode    = ConstantFlow             ! Chiller Flow Mode: ConstantFlow or VariableFlow

##set1 ChWDemandSysName = "Chilled Water Loop 1"   ! Chilled water demand side system
##set1 ChWLoopName      = "Chiller Plant"          ! Supply side plant name
##set1 ChWLoopAvailSch  = "ON"                     ! Chiller availability schedule
##set1 ChWLoopTempSch   = "CW-Loop-Temp-Schedule"  ! Chilled water setpoint schedule [C]
##set1 ChWLoopSetPoint  = 6.67                     ! Chilled water setpoint [C] if schedule=None
##set1 ChWLoopMaxTemp   = 98                       ! Max chilled water temperature [C]
##set1 ChWLoopMinTemp   = 1                        ! Min chilled water temperature [C]
##set1 ChWLoopMaxFlow   = ChillerEvWFlow[]         ! Max ChW flow (total to all zones) [m3/s]
##set1 ChWLoopMinFlow   = 0                        ! Min ChW flow (total to all zones) [m3/s]
##set1 ChWLoopVolume    = autosize                 ! ChW loop volume [m3]

! Chilled Water Pump Parameters for PUMP:VARIABLE SPEED
##set1 ChWPmpType       = "Variable"     ! ChW Pump Type [Variable or Constant]
##set1 ChWPmpHead       = 300000                 ! ChW Pump Rated Pump Head [Pa]
##set1 ChWPmpPower      = 500                    ! ChW Pump Rated Power Consumption [W]
##set1 ChWPmpMtrEff     = 0.87                   ! ChW Pump Motor Efficiency
##set1 ChWPmpMtrToFluid = 0.0                    ! ChW Pump Frac Motor Inefficiencies to Fluid
##set1 ChWPmpPtLdCoeff1 = 1.0                    ! ChW Pump Coefficient1 Part Load Perf. Curve
##set1 ChWPmpPtLdCoeff2 = 0.0                    ! ChW Pump Coefficient2 Part Load Perf. Curve
##set1 ChWPmpPtLdCoeff3 = 0.0                    ! ChW Pump Coefficient3 Part Load Perf. Curve
##set1 ChWPmpPtLdCoeff4 = 0.0                    ! ChW Pump Coefficient4 Part Load Perf. Curve
##set1 ChWPmpCtrl       = "INTERMITTENT"         ! ChW pump control type: INTERMITTENT or CONTINUOUS

ChillerSupply1[]
```

Objects generated:

> PLANT LOOP
>
> BRANCH LIST
>
> CONNECTOR LIST
>
> SPLITTER
>
> MIXER
>
> BRANCH
>
> PIPE
>
> PUMP:VARIABLE SPEED
>
> PLANT OPERATION SCHEMES
>
> LOAD RANGE BASED OPERATION
>
> COOLING LOAD RANGE EQUIPMENT LIST
>
> *Option – select one*
>
>> PURCHASED:CHILLED WATER
>>
>> CHILLER:CONST COP

(additional options will be made available)

Condenser1-Autosize[ ] *(Not implemented yet)* and Condenser1[ ]

Condenser1WithBypass-Autosize[ ]

Describes the condenser loop for a single chiller plant.

The following parameters are required for both autosize and non-autosize commands:

ChWLoopName

Name of this supply side loop – must match the chiller plant name. This name is used as a prefix for the supply-side object names and node names.

CndLoopAvailSch

Chiller loop availability schedule. See PLANT OPERATION SCHEMES for more explanation.

CndLoopTempCntrl

Loop Temperature Setpoint control type: SCHEDULED, FIXED, AIR, or GROUND. For autosized command, if omitted, defaults to AIR. See CONDENSER LOOP for more explanation.

CondenserType

Type of condenser (tower) object: COOLING-TOWER-SINGLE-SPEED or COOLING-TOWER-TWO-SPEED (non-autosized only). Uses COOLING TOWER:SINGLE SPEED or COOLING TOWER:TWO SPEED, respectively.

CndLoopTempSch

Condenser water setpoint schedule [C]. If fixed setpoint, then set this to "None". See CONDENSER LOOP for more explanation. For autosized command, if omitted, defaults to "None".

CndLoopSetPoint

Condenser water setpoint [C] if schedule="None". For a fixed setpoint, the template will generate an automatic set point schedule with this value. For autosized command, if omitted, defaults to 21C.

CndPmpType

Condenser water pump type, VARIABLE or CONSTANT speed. For autosized command, if omitted, defaults to VARIABLE.

CndPmpCtrl

Condenser water pump control type: INTERMITTENT or CONTINUOUS. See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation. For autosized command, if omitted, defaults to INTERMITTENT.

The following parameters are required only for the non-autosize command:

All parameters in the Condenser Water Loop Parameter Group (see below)

All parameters in the Condenser Water Pump Parameter Group (see below)

All parameters in the Cooling Tower Parameter Group (see below)

```
! Condenser Loop for Single Chiller Plant - Autosized
##set1 ChWLoopName     = "Chiller Plant"          ! Supply side plant name (must match chiller plant
name)
##set1 CndLoopAvailSch  = "PlantOnSched"          ! Condenser availability schedule
##set1 CndLoopTempCntrl = "AIR"                   ! Loop Temperature Setpoint control type [SCHEDULED,
                                                  !   FIXED, AIR, or GROUND] (optional, defaults to AIR)
! ##set1 CndLoopSetPoint  = 21      ! Condenser loop fixed setpoint temperature [C] (optional, defaults to
21C)
! ##set1 CndLoopTempSch   = "None"                ! Condenser loop setpoint schedule [C] or "None"
                                                  !   (optional, defaults to "None")
##set1 CondenserType     = "COOLING-TOWER-SINGLE-SPEED" ! Condenser Object Type (all dashes)
##set1 CndPmpType        = "Variable"             ! Cnd Pump Type [Variable or Constant]
##set1 CndPmpCtrl        = "INTERMITTENT"         ! Cnd pump control type: INTERMITTENT or CONTINUOUS
```

```
! Condenser Loop for Single Chiller Plant
##set1 ChWLoopName      = "Chiller Plant"            ! Supply side plant name (must match chiller plant
name)
##set1 CndLoopAvailSch  = "ON"                       ! Condenser availability schedule
##set1 CndLoopTempCntrl = "FIXED"                     ! Loop Temperature Setpoint control type [SCHEDULED,
FIXED, AIR, or GROUND]
##set1 CndLoopSetPoint  = 21                         ! Condenser loop fixed setpoint temperature [C]
##set1 CndLoopTempSch   = "None"                     ! Condenser loop setpoint schedule [C] or "None"
##set1 CndLoopMaxTemp   = 80                         ! Max condenser water temperature [C]
##set1 CndLoopMinTemp   = 5.0                        ! Min condenser water temperature [C]
##set1 CndLoopMaxFlow   = 0.0011                     ! Max condenser water flow rate [m3/s]
##set1 CndLoopMinFlow   = 0                          ! Min condenser water flow rate [m3/s]
##set1 CndLoopVolume    = autosize                    ! Condenser loop volume [m3]
##set1 CndLoopLdDist    = Sequential                 ! Load Distribution Scheme [Optimal or Sequential]

! Condenser Parameters for COOLING TOWER:SINGLE SPEED
##set1 CondenserType    = "COOLING-TOWER-SINGLE-SPEED" ! Condenser Object Type (all dashes)
##set1 CondenserCap     = 9000000000                 ! Condenser capacity [W]
##set1 CondenserAirFlow = 16.0                       ! Condenser Design Air Flow Rate [m3/s]
##set1 CondenserFanPwr  = 1000                       ! Condenser Fan Power at Design Air Flow Rate [W]
##set1 CondenserUA      = 1750.0                     ! Condenser UA value at Design Air Flow Rate [W/C]
##set1 CondenserAirFree = 0.0                        ! Condenser Air Flow Rate in Free Convection Regime
[m3/s]
##set1 CondenserUAFree  = 0.0                        ! Condenser UA value at Free Convection Air Flow Rate
[W/C]

! Condenser Parameters for COOLING TOWER:SINGLE SPEED
! ##set1 CondenserType    = "COOLING-TOWER-SINGLE-SPEED" ! Condenser Object Type (all dashes)
! ##set1 CondenserCap     = 1000000                 ! Condenser capacity [W]
! ##set1 CondenserAirHi   =                         ! Condenser Air Flow Rate at High Fan Speed [m3/s]
! ##set1 CondenserFanHi   =                         ! Condenser Fan Power at High Fan Speed [W]
! ##set1 CondenserUAHi    =                         ! Condenser UA value at High Fan Speed [W/C]
! ##set1 CondenserAirLo   =                         ! Condenser Air Flow Rate at Low Fan Speed [m3/s]
! ##set1 CondenserFanLo   =                         ! Condenser Fan Power at Low Fan Speed [W]
! ##set1 CondenserUALo    =                         ! Condenser UA value at Low Fan Speed [W/C]
! ##set1 CondenserAirFree =                         ! Condenser Air Flow Rate in Free Convection Regime
[m3/s]
! ##set1 CondenserUAFree  =                         ! Condenser UA value at Free Convection Air Flow Rate
[W/C]

! Condenser Water Pump Parameters for PUMP:VARIABLE SPEED
##set1 CndPmpType       = "Variable"      ! Cnd Pump Type [Variable or Constant]
##set1 CndPmpHead       = 300000                     ! Cnd Pump Rated Pump Head [Pa]
##set1 CndPmpPower      = 500                        ! Cnd Pump Rated Power Consumption [W]
##set1 CndPmpMtrEff     = 0.87                       ! Cnd Pump Motor Efficiency
##set1 CndPmpMtrToFluid = 0.0                        ! Cnd Pump Frac Motor Inefficiencies to Fluid
##set1 CndPmpPtLdCoeff1 = 1.0                        ! Cnd Pump Coefficient1 Part Load Perf. Curve
##set1 CndPmpPtLdCoeff2 = 0.0                        ! Cnd Pump Coefficient2 Part Load Perf. Curve
##set1 CndPmpPtLdCoeff3 = 0.0                        ! Cnd Pump Coefficient3 Part Load Perf. Curve
##set1 CndPmpPtLdCoeff4 = 0.0                        ! Cnd Pump Coefficient4 Part Load Perf. Curve
##set1 CndPmpCtrl       = "INTERMITTENT"             ! Cnd pump control type: INTERMITTENT or CONTINUOUS

Condenser1[]
```

Objects generated:

> CONDENSER LOOP
>
> BRANCH LIST
>
> CONNECTOR LIST
>
> SPLITTER
>
> MIXER
>
> BRANCH
>
> PIPE

PUMP:VARIABLE SPEED

CONDENSER OPERATION SCHEMES

COOLING LOAD RANGE BASED OPERATION

LOAD RANGE EQUIPMENT LIST

Option – select one

COOLING TOWER:SINGLE SPEED

COOLING TOWER:TWO SPEED

Chilled Water Loop Parameter Group

ChWLoopMaxFlow

Maximum chilled water flow rate (total to all coils) [m3/s]. See PLANT LOOP for more explanation.

ChWLoopMinFlow

Minimum chilled water flow (total to all coils) [m3/s]. See PLANT LOOP for more explanation.

ChWLoopTempSch

Chilled water setpoint schedule [C]. If fixed setpoint, then set this to "None". See PLANT LOOP for more explanation.

ChWLoopSetPoint

Chilled water setpoint [C] if schedule="None". For a fixed setpoint, the template will generate an automatic set point schedule with this value.

ChWLoopMaxTemp

Maximum chilled water temperature [C]. See PLANT LOOP for more explanation.

ChWLoopMinTemp

Minimum chilled water temperature [C]. See PLANT LOOP for more explanation.

ChWLoopVolume

Chilled water loop volume [m3] . May be set to "autosize". See PLANT LOOP for more explanation.

Hot Water Loop Parameter Group

HWLoopMaxFlow

Max HW flow (total to all coils) [m3/s] . See PLANT LOOP for more explanation.

HWLoopMinFlow

Min HW flow (total to all coils) [m3/s] . See PLANT LOOP for more explanation.

HWLoopTempSch

Hot water setpoint schedule [C]. If fixed setpoint, then set this to "None". See PLANT LOOP for more explanation.

HWLoopSetPoint

Hot water setpoint [C] if schedule="None". For a fixed setpoint, the template will generate an automatic set point schedule with this value.

HWLoopMaxTemp

Max HW temperature [C] . See PLANT LOOP for more explanation.

HWLoopMinTemp

Min HW temperature [C] . See PLANT LOOP for more explanation.

HWLoopVolume

HW loop volume [m3] . See PLANT LOOP for more explanation.

Condenser Water Loop Parameter Group

CndLoopMaxFlow

Maximum condenser water flow rate [m3/s]. See CONDENSER LOOP for more explanation.

CndLoopMinFlow

Minimum condenser water flow (total to all coils) [m3/s]. See CONDENSER LOOP for more explanation.

CndLoopTempSch

Condenser water setpoint schedule [C]. If fixed setpoint, then set this to "None". See CONDENSER LOOP for more explanation.

CndLoopSetPoint

Condenser water setpoint [C] if schedule="None". For a fixed setpoint, the template will generate an automatic set point schedule with this value.

CndLoopMaxTemp

Maximum condenser water temperature [C]. See CONDENSER LOOP for more explanation.

CndLoopMinTemp

Minimum condenser water temperature [C]. See CONDENSER LOOP for more explanation.

CndLoopVolume

Condenser water loop volume [m3] . May be set to "autosize". See CONDENSER LOOP for more explanation.

Chilled Water Pump Parameter Group

ChWPmpType

Chilled water pump type, "Variable" or "Constant" speed.

ChWPmpHead

Chilled water pump rated pump head [Pa]. See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation.

ChWPmpPower

Chilled water pump rated power consumption [W]. See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation.

ChWPmpMtrEff

Chilled water pump motor efficiency. See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation.

ChWPmpMtrToFluid

Chilled water pump fraction of motor inefficiencies to fluid. See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation.

ChWPmpPtLdCoeff1

ChWPmpPtLdCoeff2

ChWPmpPtLdCoeff3

ChWPmpPtLdCoeff4

These parameters are the coefficients of the chilled water pump part load performance curve. See PUMP:VARIABLE SPEED for more explanation. (Applicable only if ChWPmpType="Variable".)

ChWPmpCtrl

Chilled water pump control type: INTERMITTENT or CONTINUOUS. See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation.

Hot Water Pump Parameter Group

HWPmpType

Hot water pump type, "Variable" or "Constant" speed.

HWPmpHead

Hot water pump rated pump head [Pa]. See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation.

HWPmpPower

Hot water pump rated power consumption [W]. See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation.

HWPmpMtrEff

Hot water pump motor efficiency. See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation.

HWPmpMtrToFluid

Hot water pump fraction of motor inefficiencies to fluid. See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation.

HWPmpPtLdCoeff1

HWPmpPtLdCoeff2

HWPmpPtLdCoeff3

HWPmpPtLdCoeff4

These parameters are the coefficients of the hot water pump part load performance curve. See PUMP:VARIABLE SPEED for more explanation.   (Applicable only if HWPmpType="Variable".)

HWPmpCtrl

Hot water pump control type: INTERMITTENT or CONTINUOUS. See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation.

Condenser Water Pump Parameter Group

CndPmpType

Condenser water pump type, "Variable" or "Constant" speed.

CndPmpHead

Condenser water pump rated pump head [Pa].   See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation.

CndPmpPower

Condenser water pump rated power consumption [W]. See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation.

CndPmpMtrEff

Condenser water pump motor efficiency.   See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation.

CndPmpMtrToFluid

Condenser water pump fraction of motor inefficiencies to fluid. See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation.

CndPmpPtLdCoeff1

CndPmpPtLdCoeff2

CndPmpPtLdCoeff3

CndPmpPtLdCoeff4

These parameters are the coefficients of the condenser water pump part load performance curve.   See PUMP:VARIABLE SPEED for more explanation.   (Applicable only if CndPmpType="Variable".)

CndPmpCtrl

Condenser water pump control type: INTERMITTENT or CONTINUOUS.   See PUMP:VARIABLE SPEED or PUMP:CONSTANT SPEED for more explanation.

Boiler Parameter Group

BoilerCap

Boiler capacity [W].   See BOILER:SIMPLE   or PURCHASED:HOT WATER for more explanation.

The following parameters are only required if BOILER:SIMPLE is the selected boiler type:

BoilerFuel

Boiler fuel type.   The fuel type can be Electricity, NaturalGas, PropaneGas, FuelOil#1, FuelOil#2, Coal, Diesel, or Gasoline.   See BOILER:SIMPLE for more explanation.

BoilerEffic

Boiler Theoretical Efficiency.   See BOILER:SIMPLE for more explanation.

BoilerMinPtLd

Boiler Minimum Part Load Ratio.   See BOILER:SIMPLE for more explanation.

BoilerMaxPtLd

Boiler Maximum Part Load Ratio.   See BOILER:SIMPLE for more explanation.

BoilerOptPtLd

Boiler Optimum Part Load Ratio.   See BOILER:SIMPLE for more explanation.

BoilerPtLdCoeff1

Boiler Coefficient1 Part Load Perf. Curve.   See BOILER:SIMPLE for more explanation.

BoilerPtLdCoeff2

Boiler Coefficient2 Part Load Perf. Curve.   See BOILER:SIMPLE for more explanation.

BoilerPtLdCoeff3

Boiler Coefficient3 Part Load Perf. Curve.   See BOILER:SIMPLE for more explanation.

BoilerFlowMode

Boiler Flow Mode: ConstantFlow or VariableFlow. . See BOILER:SIMPLE for more explanation.

Chiller Parameter Group

ChillerCap

Chiller capacity [W]. See CHILLER:CONST COP or PURCHASED:CHILLED WATER for more explanation.

The following parameters are only required if CHILLER:CONST COP is the selected boiler type:

ChillerCOP

Chiller COP. See CHILLER:CONST COP for more explanation.

ChillerEvWFlow

Chiller evaporator vol flow rate [m3/s]. 4.312E-8 m3/s per W of cooling capacity is equivalent to 2.4 gpm per ton. See CHILLER:CONST COP for more explanation.

ChillerCdWFlow

Chiller condenser vol flow rate [m3/s]. 5.39E-8 m3/s per W of cooling capacity is equivalent to 3 gpm per ton. See CHILLER:CONST COP for more explanation.

ChillerCondType

Chiller condenser type: WATER COOLED, AIR COOLED, or EVAP COOLED. See CHILLER:CONST COP for more explanation.

ChillerFlowMode

Chiller Flow Mode: ConstantFlow or VariableFlow. See CHILLER:CONST COP for more explanation.

Cooling Tower Parameter Group

The following parameters are applicable to both COOLING TOWER:SINGLE SPEED and COOLING TOWER:TWO SPEED:

CondenserCap

Condenser capacity [W].   See COOLING TOWER:SINGLE SPEED or COOLING TOWER:TWO SPEED for more explanation.

CondenserAirFree

Condenser Air Flow Rate in Free Convection Regime [m3/s] .   See COOLING TOWER:SINGLE SPEED or COOLING TOWER:TWO SPEED for more explanation.

CondenserUAFree

Condenser UA value at Free Convection Air Flow Rate [W/C] .   See COOLING TOWER:SINGLE SPEED or COOLING TOWER:TWO SPEED for more explanation.

The following parameters are applicable to only COOLING TOWER:SINGLE SPEED:

CondenserAirFlow

Condenser Design Air Flow Rate [m3/s]. See COOLING TOWER:SINGLE SPEED for more explanation.

CondenserFanPwr

Condenser Fan Power at Design Air Flow Rate [W]. See COOLING TOWER:SINGLE SPEED for more explanation.

CondenserUA

Condenser UA value at Design Air Flow Rate [W/C]. See COOLING TOWER:SINGLE SPEED for more explanation.

End COOLING TOWER:SINGLE SPEED parameters.

The following parameters are applicable to only COOLING TOWER:TWO SPEED:

CondenserAirHi

Condenser Air Flow Rate at High Fan Speed [m3/s]. See COOLING TOWER:TWO SPEED for more explanation.

CondenserFanHi

Condenser Fan Power at High Fan Speed [W]. See COOLING TOWER:TWO SPEED for more explanation.

CondenserUAHi

Condenser UA value at High Fan Speed [W/C]. See COOLING TOWER:TWO SPEED for more explanation.

CondenserAirLo

Condenser Air Flow Rate at Low Fan Speed [m3/s]. See COOLING TOWER:TWO SPEED for more explanation.

CondenserFanLo

Condenser Fan Power at Low Fan Speed [W]. See COOLING TOWER:TWO SPEED for more explanation.

CondenserUALo

Condenser UA value at Low Fan Speed [W/C]. See COOLING TOWER:TWO SPEED for more explanation.

End COOLING TOWER:TWO SPEED parameters.

WinEPDraw

Introduction

The WinEPDraw program is a simple utility that can be used to generate a dxf file of the an input file without going entirely through the input scan for EnergyPlus. It is a simple Windows™ applet that is stored in the primary EnergyPlus folder upon installation.
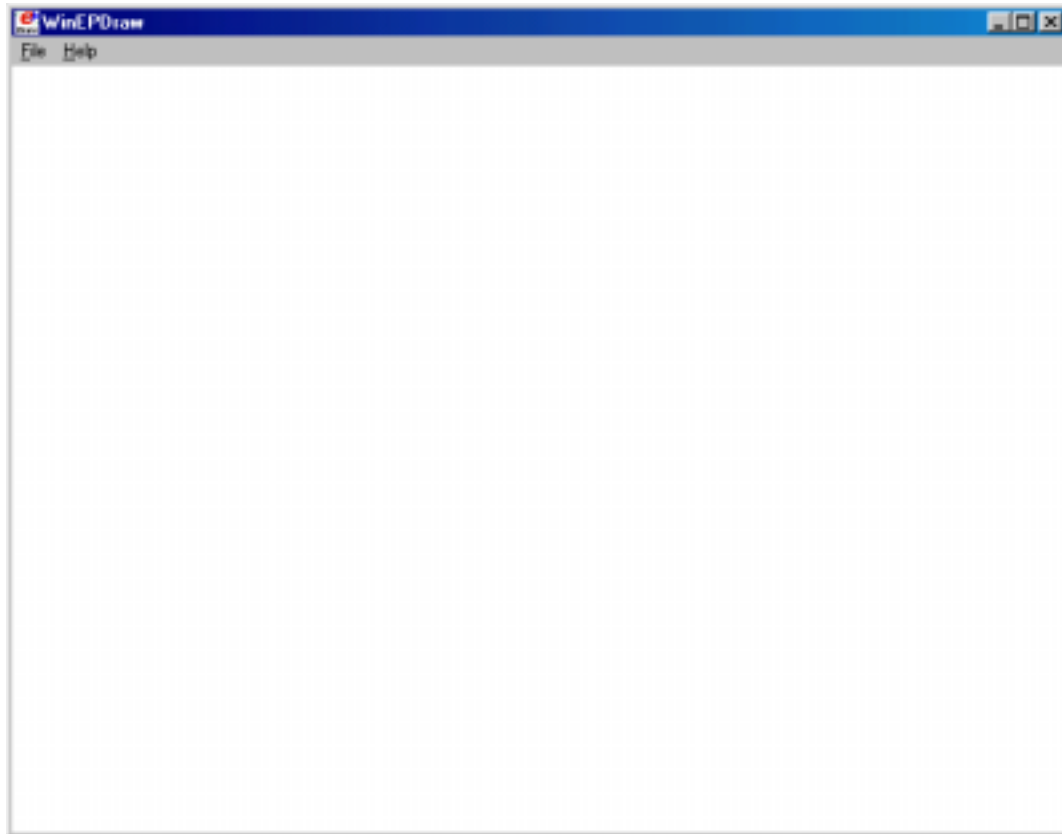
Figure 10. WinEPDraw Main Screen

Choosing the File->Open menu, the standard common dialog is displayed:
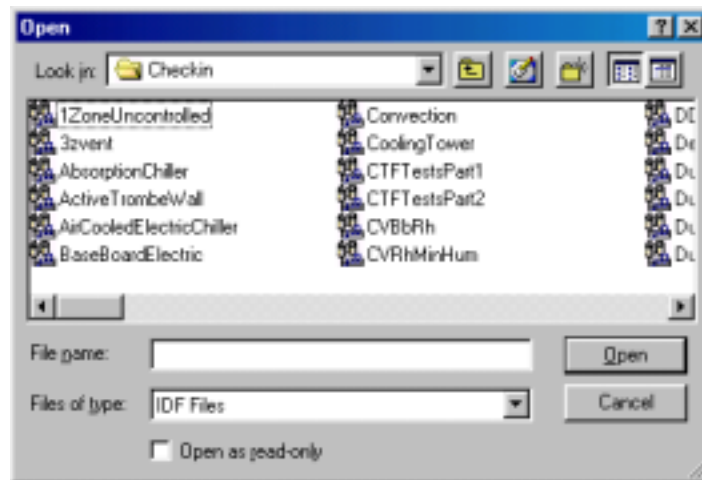
Figure 11. Dialog for WinEPDraw File Selection

Currently, only IDF files can be processed. Select one and it will be read in and a DXF file will be produced in the same folder as the original IDF file. Then, a message box will appear notifying you that the process was successful (or that it failed). If it failed, no DXF file is produced.

You may process as many IDFs as you like during WinEPDraw execution.

To exit the program, choose File->Exit menu.

Input Macros

Introduction

The Input Macros feature increases the flexibility of the EnergyPlus input files. This feature is intended for advanced users who are already familiar with EnergyPlus IDF files and need to prepare input manually. The basic capabilities are:

- Incorporating external files containing pieces of IDF into the main EnergyPlus input stream.

- Selectively accepting or skipping portions of the input.

- Defining a block of input with parameters and later referencing this block.

- Performing arithmetic and logical operations on the input.

- Input macro debugging and listing control.

These capabilities are invoked in the EP-MACRO program by using macro commands. Macro commands are preceded by ## to distinguish them from regular EnergyPlus input commands.   After execution by the EP-MACRO processor, macro commands produce regular lines of EnergyPlus input that are shown in the resultant IDF file (**out.idf**) and, subsequently, in the EnergyPlus echo print (**audit.out**). Following are descriptions of the macro commands associated with the above capabilities. A detailed example of input macros is given at the end of this section; you should review it before reading the macro command descriptions.

Incorporating External Files

##include {includefilename}

This command puts all of the lines in an external file into the EnergyPlus input stream starting right after the command line. The name of the file that is included is the concatenation of {prefixpathname}, entered using **##fileprefix** , and {includefilename}.   The lines in the external file will be listed in the resultant IDF file. When all the lines in the external file have been read in, input reverts back to the original input file at the line following the **##include** command.

##fileprefix {prefixpathname}

specifies a pathname that will be prefixed to the filename given in an **##include** command. The **##fileprefix** command allows commonly-used include files to be kept in a directory other than the directory in which the current input file resides.

Example: on a PC, the combination

##fileprefix C:\EnergyPlus\Library

##include SCHEDULES.IDF

will include into the EnergyPlus input stream the file whose full name is

C:\EnergyPlus\Library\SCHEDULES.IDF

##includesilent {includefilename}

This command is identical to **##include**, except that the lines in the included file will not be listed in the EP-MACRO echo.

##nosilent

Overrides the listing suppression of **##includesilent**. Used for debugging purposes only. After **##nosilent** , all following **##includesilent** commands are treated as **##include** commands.

Example: Assume the following files contain the indicated lines:

Main input file: input1.inp	External file: file2.inp
line 1a	line 2a
##include file2.inp	line 2b
line 1b	line 2c
line 1c	

The end result of processing **##include** input1.inp will be:

```
line 1a   (from input1.inp)
line 2a   (from file2.inp)
line 2b   (from file2.inp)
line 2c   (from file2.inp)
line 1b   (from input1.inp)
line 1c   (from input1.inp)
```

External files can also contain **##include** commands, as shown in the following example:

Main input file: input1.inp	First external file: file2.inp	Second external file: file3.inp
line 1a	line 2a	line 3a
##include file2.inp	line 2b	line 3b
line 1b	**##include** file3.inp	line 3c
line 1c	line 2c	line 3d

The end result of processing **##include** input1.tmp will be:

```
line 1a   (from input1.inp)
line 2a   (from file2.inp)
line 2b   (from file2.inp)
line 3a   (from file3.inp)
line 3b   (from file3.inp)
line 3c   (from file3.inp)
line 3d   (from file3.inp)
line 2c   (from file2.inp)
line 1b   (from input1.inp)
line 1c   (from input1.inp)
```

Note: Up to nine **##include** commands can be nested. However, there should be no recursion. This is an example of a recursion:

file1.inp contains **##include** file2.inp

file2.inp contains **##include** file1.inp

Selectively Accepting or Skipping Lines of Input

The **##if** series of commands is used to selectively accept or skip lines of input according to the following sequence:

```
##if {condition1}
  line1a
  line1b
```

```
….

##elseif  {condition2}
   line2a
   line2b


##elseif  {condition3}
   line3a
   line3b
….

##else
   line N a
   line N b
….

##endif
```

Then the lines that will be included into the EnergyPlus input stream are:

```
If {condition 1} is TRUE,
  line1a
  line1b
….
otherwise

If {condition 2} is TRUE,
  line2a
  line2b
….
otherwise

If {condition 3} is TRUE,
  line3a
  line3b
….

otherwise

If {condition 1}, {condition 2}, {condition 3} are all FALSE.
  line N a
  line N b
….
```

There are six different **##if...** commands:

Command		Result
##ifdef	{macro name}	: if macro name defined, include following lines
##ifndef	{macro name}	: if macro name NOT defined, include following lines
##if	{condition}	: if condition is TRUE, include following lines
##elseif	{condition}	: if condition is TRUE, and previous conditions are FALSE, include following lines
##else		: if all previous conditions are FALSE, include following lines
##endif		: indicates the end of the if block
Notes:		
{macro name} is explained in section *Defining Blocks of Input*, below.		

{condition} is 0 or BLANK meaning FALSE, and any other character meaning TRUE.
##ifdef and **##ifndef** do not have corresponding **##elseif** commands, but they do have corresponding **##else** and **##endif** commands.

Defining Blocks of Input

The **##def** command allows a block of input text to be defined and given a name. The block of text can then be inserted anywhere in the EnergyPlus input stream by simply referencing the name of the block. (This process is called macro expansion.) The block can have parameters (also called arguments) that can be given different values each time the block is referenced.

The syntax of the **##def** command is as follows:

```
        unique name
            |            zero or more arguments    __ macro text
            |                |                      |
            |                |                      |

    ##def  macro-name [ arg1 arg2,arg3 ...]   text line 1

  |_      |            | |   |_    |   _|     |
    |     |            | |    |    |   |      |__ one
    |     |            | |    |    |   |          or
zero    one         zero_|   space(s)          more
or      or          or       or comma          spaces
more    more        more
spaces  spaces      spaces
```
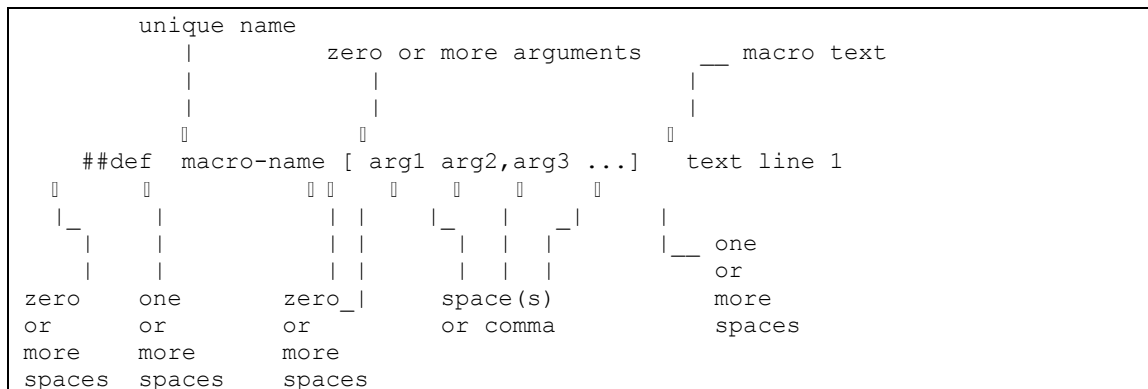
Example: Define a schedule macro with name "All_Const":

```
##def All_Const[x]
        Fraction, WeekON, 1,1, 12,31;
    WEEKSCHEDULE, WeekON,
        DayON,DayON,DayON,
        DayON,DayON,DayON,
        DayON,DayON,DayON,
        DayON,DayON,DayON;
    DAYSCHEDULE, DayON, Fraction,
        x,x,x,x,x,x,x,x,x,x,x,x,
        x,x,x,x,x,x,x,x,x,x,x,x ;
##enddef
```

Then, in the EnergyPlus input stream (file in.imf), when we write :

```
SCHEDULE, Constant At 0.8, All_Const[0.8]
```

the result (file out.idf) is equivalent to:

```
SCHEDULE, Constant At 0.8,
        Fraction, WeekON, 1,1, 12,31;
    WEEKSCHEDULE, WeekON,
        DayON,DayON,DayON,
        DayON,DayON,DayON,
        DayON,DayON,DayON,
        DayON,DayON,DayON;
    DAYSCHEDULE, DayON, Fraction,
        0.8,0.8,0.8,0.8,0.8,0.8,0.8,0.8,0.8,0.8,0.8,0.8,
        0.8,0.8,0.8,0.8,0.8,0.8,0.8,0.8,0.8,0.8,0.8,0.8 ;
```

Macro definitions may have one or more arguments; the maximum number of arguments is 32. When a macro with arguments is referenced, its arguments must be given values. When

a macro has no arguments, the brackets are still required both for macro definition and reference.

> Caution: Square brackets [ ] have been used in some versions of EnergyPlus inputs as comment/units fields. These will be expanded if left in the IDF and sent to EPMacro.

Macro names must be unique (except see **##set1** below); i.e., when a macro name is defined it cannot be defined again. Macro names are limited to 40 characters.

To summarize, commands you use to define macros are the following:

##def   macro-name [**arg1**,..,**arg*n***] macro-text

Defines a macro with the name macro-name and arguments "arg1" through "arg*n*". "Macro-text" is one or more lines of text. If there are no arguments, the syntax is **##def** macro-name macro-text.

##enddef

Indicates the end of the macro definition initiated by **##def.**

##def1   macro-name [**arg1**,..,**arg*n***] macro-text

This is the same as **##def** but there is only one line of text so that the terminating command **##enddef** is not required.

##set1   macro-name   macro-text

Like **##def1** but has no arguments and macro-text is evaluated before storing. "Macro-text is evaluated" means that if macro-text contains other macros, these macros will be expanded, and the expanded text becomes the macro-text defined by **##set1**.

Example:

```
                      ##def1   xx   123
                      ##set1   yy   xx[]

is equivalent to:   ##set1   yy   123

##set1   can also be used to redefine macro-name.

##set1   x    0
   .
   .
   .
##set1   x     #eval[ x[]+1 ]

(see Arithmetic Operations for description of the #eval macro.)
```

Arithmetic Operations

The built-in macro called **#eval[ ]** can be used to perform arithmetic, literal, and logical operations. It can be abbreviated to **# [ ].**

#eval[X OP Y] or #[X OP Y]

gives the result X OP Y. The allowed values for X, OP, and Y, and the corresponding result, are shown in the following table.

X *	OP **	Y	Result
number	+ (plus)	number	number
number	- (minus)	number	number

number	* (times)	number	number
number	/ (divided by)	number	number
number	min	number	number
number	max	number	number
number	mod	number	number
number	** (power)	number	number
SIN	OF	number (degrees)	number
COS	OF	number (degrees)	number
TAN	OF	number (degrees)	number
SQRT	OF	number	number
ABS	OF	number	number
ASIN	OF	number	number (degrees)
ACOS	OF	number	number (degrees)
ATAN	OF	number	number
INT	OF	number	number
LOG10	OF	number	number
LOG	OF	number	number
literal1	// (concatenate)	literal2	literal "literal1literal2"
literal1	/// (concatenate)	literal2	literal "literal1 literal2"
literal	EQS (=)	literal	logical (true or false)
literal	NES (≠)	literal	logical (true or false)
logical	AND	logical	logical (true or false)
logical	OR	logical	logical (true or false)
	NOT	logical	logical (true or false)
number	EQ (=)	number	logical (true or false)
number	NE (≠)	number	logical (true or false)
number	GT (>)	number	logical (true or false)
number	GE (≥)	number	logical (true or false)
number	LT (<)	number	logical (true or false)
number	LE (≤)	number	logical (true or false)
* Upper or lower case is allowed for SIN, COS, etc.			
** Upper or lower case is allowed for OF, EQS, etc.			

Example

#eval[1 + 2 **]**   when expanded becomes 3.

#eval[1 + **#eval**[2 * 3] **]** when expanded becomes 7.

Example

##set1 city[] Washington

  DesignDay, #[city[ ] /// SUMMER], ! Design Day Name

gives

    DesignDay, "Washington SUMMER", ! Design Day Name

The following example illustrates the use of **#eval** inside **#if** commands:

##if #[city[ ] EQS Chicago **]**

##if #[#[city[ ] EQS Chicago] and #[occup[ ] NES low]]

Notes:

1.   For logical values:

False = 0 or BLANK,

True = any other character

2.   A literal must be enclosed inside a pair of double quotes if it contains BLANKs or reserved characters like [ ] ( ) ,

E.g., "abc *def"

Otherwise, the quotes around the literals are optional.

3.   Literal concatenation operators // and /// produce quoted literals.

E.g., # [large /// office]   gives "large office"

4.   Literals are case sensitive.   For example, "Chicago", "CHICAGO" and "chicago" are distinct.

5.   Literals are limited to 40 characters.

Macro Debugging and Listing Control

##list

Turn on listing; echo of input lines on the OUTPUT file is enabled. This is the default condition.

##nolist

Turn off listing; echo of input lines on the output file is disabled.

##show

Start printing expanded line on output file. After this command, if a macro expansion was done, the expanded line is printed on the output file. In this way you can see the end result of macro expansions, which is the input as seen by the EnergyPlus Input processor.

##noshow

Stop printing expanded line on output file. This is the default condition.

##showdetail

Start printing each macro expansion. After this command, every time a macro expansion is done the result of the expansion is printed. This can produce lots of output.

##noshowdetail

Stop printing each macro expansion. This is the default condition.

##traceback

Give full traceback when printing an error message. After this command, if there is a EP-MACRO error, a full traceback of the macro expansions in progress is printed. This is the default condition.

##notraceback

Don't give full traceback when printing an error message.

##write

Start writing expanded text into file 22. This is similar to **##show** except that the expanded lines are written into file 22. Therefore, file 22 will contain only the text that will be seen by the EnergyPlus processor. This file is used only for debugging purposes. It allows you to see what the macro-processed input file looks like.

##nowrite

Stop writing expanded text into file 22. This is the default condition.

##symboltable

Prints table of current macro names. All of the macro names that are defined will be printed.

##clear

Clear all macro definitions. All the macro names defined up to this point will be deleted.

##reserve TEXT *k* NAMES *l* STACK *m*

Allocates memory.

Reserves   *k*   words of space in AA array for macro definition storage.

Reserves   *l*   positions in macro definition names table.

Reserves   *m*   words of stack space.

If used, the **##reserve** command must precede all other macro commands in the EP-MACRO input. This command should be used only if one or more of the following error messages is received:

"Need more memory for storing macro definitions"

Use "**##reserve** TEXT nnnnnn" command to get more memory. Current value of *nnnnnn* is: _ _ _

"Macro table capacity exceeded"

Use "**##reserve** NAMES nnnnnn" command to get more memory. Current value of *nnnnnn* is: _ _ _

"Macro stack overflow"

Use "**##reserve** STACK nnnnnn" command to get more memory. Current value of *nnnnnn* is: _ _ _

##$ <comment>

Allows you to enter comment lines inside a macro. **<comment>** is printed in the EP-MACRO echo but is not acted on by the macro processor.

Example:

This example shows the use of the **##set**, **##include**, **##eval** and **##if** commands. Let an external file called cities.idf contain the following text:

```
##if #[ city[ ] EQS CHICAGO ]
  Location,Chicago IL,  !- Location Name
   41.880,  !- Latitude
   -87.63,  !- Longitude
   -6.0,    !- Time Zone
   2.;      !- Elevation {m}
##elseif #[ city[ ] EQS WASHINGTON ]
  Location,Washington DC,  !- Location Name
   38.9,   !- Latitude
   -77.0,  !- Longitude
   -5.0,   !- Time Zone
```

```
    15.;     !- Elevation {m}
##else
  ERROR --- City Undefined
##endif
```

Then the EnergyPlus input

```
##set1 city[ ] CHICAGO
##include cities.idf
```

will be converted, after macro processing, to:

```
Location,Chicago IL,  !- Location Name
   41.880,  !- Latitude
   -87.63,  !- Longitude
   -6.0,    !- Time Zone
   2.;      !- Elevation {m}
```

Listing Format

The format of listing from EP-MACRO gives information about the status of the input macros, as shown in the following:

```
1. 1.1  * 123 * ......  EnergyPlus input line
-  - -  -------  --------------------------------

| | |      |       echo of EnergyPlus input line
| | |      |
| | |     line number ( if the current line is being skipped
| | |                   by " ##if... " etc, this is indicated
| | |                   by printing "- 123 -" instead of
| | |                   "* 123 *" in the line number field;
| | |                   if the current line is part of a
| | |                   macro command, it is indicated by
| | |                   printing "# 123 #" )
| | |
| | macro expansion nesting level
| |
|"##if" nesting level
|
"##include" nesting level
```